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SAVING THE SAVABLE: USING BYSTANDERS TO INCREASE SURVIVAL FROM OUT-OF-HOSPITAL CARDIAC ARREST (OHCA) IN NEW YORK CITY

by

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March 2016

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   Every year in America, thousands of people needlessly die following out-of-hospital cardiac arrest (OHCA). Because first responders in New York City (NYC) have difficulty arriving soon enough, cardiac arrest survival rates lag significantly behind jurisdictions around the country. One successful approach used elsewhere to increase OHCA survival rates is encouraging bystanders to perform CPR prior to first responders' arrival. Regarding bystanders as the "first" first responders requires a shift in thinking as well as an understanding of the modern bystander. This thesis examines the people, policies, and technology that are available—some of them already tested in other jurisdictions—and presents specific recommendations for NYC. Bridging the gap from the time a person stops breathing until the arrival of first responders may not be as difficult as it seems.

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FROM OUT-OF-HOSPITAL CARDIAC ARREST (OHCA) IN NEW YORK CITY**

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ABSTRACT

Every year in America, thousands of people needlessly die following out-of-hospital cardiac arrest (OHCA). Because first responders in New York City (NYC) have difficulty arriving soon enough, cardiac arrest survival rates lag significantly behind jurisdictions around the country. One successful approach used elsewhere to increase OHCA survival rates is encouraging bystanders to perform CPR prior to first responders' arrival. Regarding bystanders as the "first" first responders requires a shift in thinking as well as an understanding of the modern bystander. This thesis examines the people, policies, and technology that are available—some of them already tested in other jurisdictions—and presents specific recommendations for NYC. Bridging the gap from the time a person stops breathing until the arrival of first responders may not be as difficult as it seems.

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LIST OF ACRONYMS AND ABBREVIATIONS

AED	Automated External Defibrillator
AEMT	Advanced Emergency Medical Technician
AHA	American Heart Association
ALS	Advanced Life Support
BLS	Basic Life Support
CARES	Cardiac Arrest Registry to Enhance Survival
CFR	Certified First Responder
CPR	Cardio-Pulmonary Resuscitation
EMD	Emergency Medical Dispatcher
EMR	Emergency Medical Responder
EMS	Emergency Medical Services
EMT	Emergency Medical Technicians
FDNY	City of New York, Fire Department
GPS	Global Positioning Systems
ICD	Implantable Cardioverter Defibrillator
JAMA	Journal of the American Medical Association
MAC	Media Access Control Address
NFC	Near Field Communication
NHTSA	National Highway Traffic Safety Administration
NFPA	National Fire Protection Association
NYC	New York City
OCHA	Out-of-Hospital Cardiac Arrest
PAD	San Ramon Valley Public Access Defibrillation Community Partnership
PHASE	Prehospital Arrest Survival Evaluation
PHENYCS	Prehospital Evaluation of New York City Survival
RFID	Radio frequency Identification
ROSC	Return of Spontaneous Circulation
STS	Socio-Technical Systems
T-CPR	Telecommunicator-Cardio-Pulmonary Resuscitation

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EXECUTIVE SUMMARY

For most EMS systems, arriving in less than four minutes at the side of a patient whose arrest resulted in a 911 call is nearly impossible.

—John Freese, FDNY Office of Medical Affairs

Every year in America, thousands of people needlessly die following out-of-hospital cardiac arrest (OHCA). These fatalities account for 15 percent of all domestic deaths.[1] In New York City (NYC), cardiac arrest survival rates lag significantly behind a number of other jurisdictions. The problem is that first responders need to be notified, respond, arrive at the location, locate the patient, and begin CPR in under four minutes, beginning from the time a victim stops breathing. Newer research suggests that, beyond the four-minute mark, few patients survive.[2] This means that the conventional calculation—that cardiac arrest survival drops steadily by 7 percent to 10 percent for each minute that CPR and defibrillation is delayed—is not accurate.[3] This rapid response is difficult to accomplish anywhere; given NYC's urban traffic congestion, distant suburban response areas, and the rapidly increasing number of high-rise structures, a concerning picture emerges. This problem shows that traditional methods of response and system measurement are problematic, and necessitates new thinking about the problem of cardiac arrest.

One successful approach used elsewhere is to encourage bystanders to perform CPR prior to first responders' arrival. Bystanders can bridge the gap from the time a person stops breathing until CPR begins, significantly increasing the probability of

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[1] Dariush Mozaffarian et al., *Heart Disease and Stroke Statistics—2015 Update: A Report from the American Heart Association* (Dallas, TX: American Heart Association, 2015), doi 10.1161/CIR.0000000000000152; "Cardiac Arrest Statistics," American Heart Association, accessed October 26, 2014, http://www.heart.org/HEARTORG/General/Cardiac-Arrest-Statistics_UCM_448311_Article.jsp.

[2] John Freese, "Shifting the Curve: Increasing Cardiac Arrest Survival in NYC," *FDNY Office of Medical Affairs Continuing Medical Education—News & Information*, 14, no. 6 (June 2008): 4–14, http://www.nysvara.org/news/2008/jul/080707.pdf.

[3] American Heart Association. "Cardiac Arrest Statistics." Accessed October 26, 2014. http://cpr.heart.org/AHAECC/CPRAndECC/General/UCM_477263_Cardiac-Arrest-Statistics.jsp.

survival. An analysis of the available studies on NYC and the systems in place demonstrate that there has been an increase in OHCA survival. Indeed, NYC has reduced response times and implemented many successful programs and policies aimed at improving survival. Still, bystander CPR rates have been consistent throughout all of the studies, remaining in a range from 32 to 37 percent.[4] With the right policies, people, and a little help from technology to facilitate bystander participation many of these needless deaths can be prevented.

This thesis examines the people, policies, and technology that are available—some of them already tested in other jurisdictions—and presents specific recommendations for NYC. The proposed recommendations build on particular observations about the current emergency response system in NYC, specifically on the relationship between first responders, bystander participation, and the environment in which they interact to help those in cardiac arrest.

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[4] Freese, "Shifting the Curve," 7.

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required of such a rigorous program. I am forever grateful for my wife, Lynn, and my two children, Jessica and Justin.

Finally, this thesis is dedicated to my brother Bobby. Bobby was 36 years old when he passed away after suffering OHCA. Although a bystander initiated a call for help by dialing 911, like so many others, this bystander failed to become involved and did not perform the lifesaving function of CPR. I look forward to the day that needless deaths from OHCA can be prevented, and we will save the savable.

I. INTRODUCTION

Some 360,000 Americans suffer out-of-hospital cardiac arrests (OHCA) each year, accounting for 15 percent of all domestic deaths and claiming the lives of roughly 1,000 people each day.[1] After the onset of cardiac arrest, there is a small window of increased opportunity for survival—about four minutes.[2] In New York City (NYC), the OHCA survival rate is not as high as other areas around the country.[3] Among other reasons, NYC's dedicated and professional first responders are often unable to arrive soon enough to aid victims of cardiac arrest because of urban traffic congestion, distant suburban response areas, and high-rise structures. However, increasing civic engagement—in the form of bystander cardio-pulmonary resuscitation (CPR)—may provide the needed bridge from the time of collapse until the arrival of first responders, thereby increasing a victim's chance of survival and preventing needless deaths.

This thesis asks: How can NYC increase the survival rate from out-of-hospital cardiac arrest? Reducing the time between loss of breath and CPR is relevant to homeland security because of the high mortality rate associated with OHCA. With more than 80 percent of the U.S. population now residing in urban areas, the recommendations provided by this research can apply to any jurisdiction seeking to improve OHCA survival.[4]

To build these recommendations, this thesis examines the people, policies, and technology that are available—some of them already tested in other jurisdictions—and

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[1] Dariush Mozaffarian et al., *Heart Disease and Stroke Statistics—2015 Update: A Report from the American Heart Association* (Dallas, TX: American Heart Association, 2015), doi 10.1161/CIR.00000 00000000152.

[2] John Freese, "Shifting the Curve: Increasing Cardiac Arrest Survival in NYC," *FDNY Office of Medical Affairs Continuing Medical Education—News & Information*, 14, no. 6 (June 2008): 4–14, http://www.nysvara.org/news/2008/jul/080707.pdf.

[3] "King County Has World's Highest Survival Rate for Cardiac Arrest," King County, last modified January 28, 2015, http://kingcounty.gov/depts/health/news/2014/May/19-cardiac-survival.aspx.

[4] "Frequently Asked Questions," U.S. Census Bureau, accessed January 13, 2016, https://ask.census.gov/faq.php?id=5000&faqId=5971.

specific considerations for NYC's urban environment to form specific recommendations for NYC.

A.   SURVIVING CARDIAC ARREST

A certain chain of events must occur if a victim of cardiac arrest, especially OHCA, is to survive. This section introduces the five steps in the Chain of Survival and the significance of timely CPR in conjunction with defibrillation. It also establishes the need for intervention within four minutes and identifies the standards for response times by which first responders are evaluated today. Finally, it discusses the context in which professional first responders and bystanders can and do render aid.

1.   The Chain of Survival

The American Heart Association uses a metaphor for the elements of the emergency cardiovascular care system concept called the Chain of Survival (see Figure 1).[5] The Association explains that "a strong Chain of Survival can improve chances of survival and recovery for victims of heart attack, stroke and other emergencies."[6] There are five links in the adult Chain of Survival: "immediate recognition and activation of the emergency response system, early CPR with an emphasis on chest compressions, rapid defibrillation, effective advanced life support, and integrated post cardiac care."[7] When a link in the Chain of Survival is improved, so is the victim's chance of survival.

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[5] "Out-of-Hospital Chain of Survival," American Heart Association, accessed September 26, 2014, http://www.heart.org/HEARTORG/CPRAndECC/WhatisCPR/AboutEmergencyCardiovascularCareECC/Chain-of-Survival_UCM_307516_Article.jsp.

[6] "Out-of-Hospital Chain of Survival," American Heart Association.

[7] Ibid.

Figure 1.   Chain of Survival
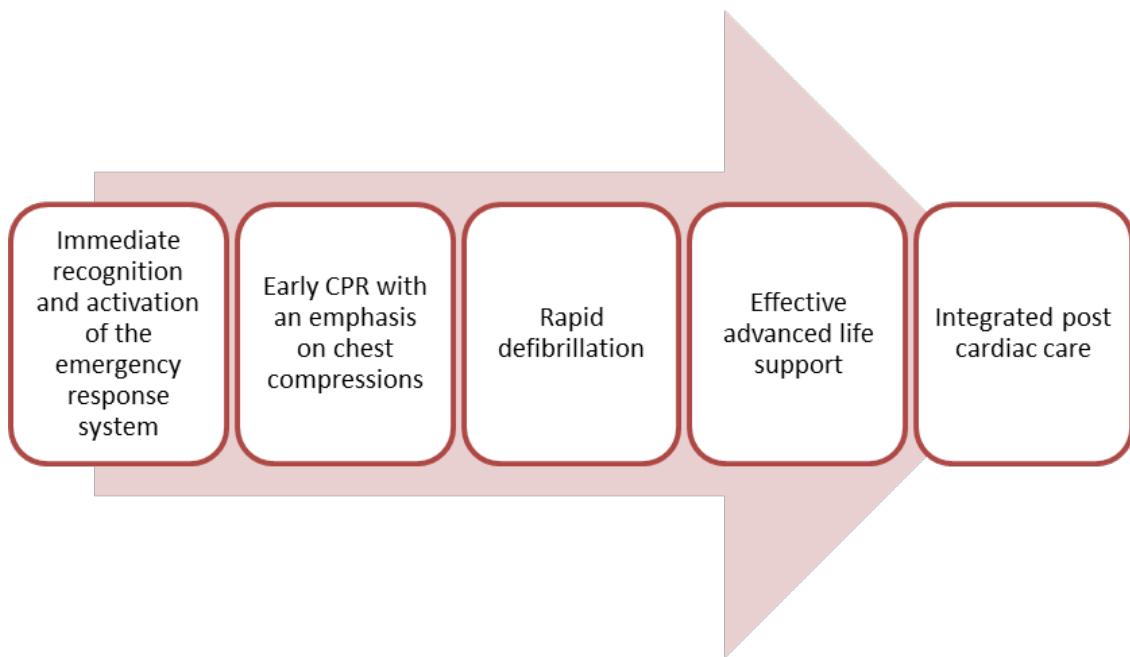
Adapted from "Out-of-Hospital Chain of Survival," American Heart Association, accessed September 26, 2014, http://www.heart.org/HEARTORG/CPRAndECC/WhatisCPR/AboutEmergency CardiovascularCareECC/Chain-of-Survival_UCM_307516_Article.jsp.

2.   The CPR Curve and the Significance of Timely CPR

According to the American Heart Association, in 2012 and 2013 more than 740,000 people in the United States experienced an out-of-hospital cardiac arrest.[8] Approximately 90 percent of these people died.[9] Of those who died, the majority—almost 60 percent—did not receive bystander-assisted CPR or defibrillation.[10]

In medical emergencies, sudden cardiac arrest may become irreversible if advanced life support (ALS) is not implemented early. The American Heart Association states that "survival is directly linked to the amount of time between the onset of sudden cardiac arrest and defibrillation. If no bystander CPR is provided, a victim's chances of

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[8] "Cardiac Arrest Statistics," American Heart Association.

[9] Ibid.

[10] Ibid.

survival are reduced by 7 percent to 10 percent with every minute of delay until defibrillation" (see Figure 2).[11]

Figure 2.   Traditional CPR Time / Success Curve

However, the traditional CPR time/success curve (in which there occurs a 7–10-percent drop for every minute of delay) may not accurately reflect the significance of the first four minutes following cardiac arrest. Newer research suggests that there is a steep drop from zero (time of arrest) to four minutes; beyond the four-minute mark, the survivability curve runs almost flat (see Figure 3).[12] This observation begs the importance of new thinking when it comes to cardiac arrest.

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[11] Ibid.

[12] John Freese, "Shifting the Curve: Increasing Cardiac Arrest Survival in NYC," *FDNY Office of Medical Affairs Continuing Medical Education—News & Information*, 14, no. 6 (June 2008): 4–14, http://www.nysvara.org/news/2008/jul/080707.pdf.

Figure 3.   The Four-Minute Survival Curve
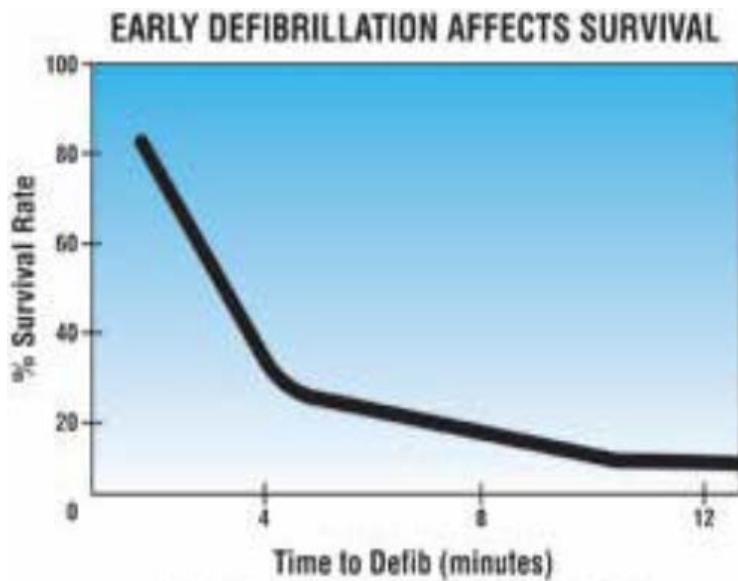
Each minute that passes with defibrillation may reduce the patient's chance for survival by up to 10 percent. Source: John Freese, "Shifting the Curve: Increasing Cardiac Arrest Survival in NYC," *FDNY Office of Medical Affairs Continuing Medical Education—News & Information*, 14, no. 6 (June 2008): 4–14, http://www.nysvara.org/news/2008/jul/080707.pdf.

During the first four minutes after a heart attack, the odds for survival are high; after four minutes (along the flat curve in Figure 3) the odds decrease sharply. Incorporating this newer analysis requires a greater emphasis on the first four minutes—during the decreased window of opportunity following cardiac arrest—and on the importance of bystander CPR.

3.   Automated External Defibrillators

The use of automated external defibrillators (AEDs) by medical service personnel dates back to the 1970s.[13] In 1999, The Cardiac Survival Act established the guidelines for placing AEDs in federal buildings.[14] Also in 1999, Chicago's O'Hare and Midway Airports installed AEDs; during the first 10 months following the installation, a

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[13] Occupational Safety and Health Administration (OSHA), *Cardiac Arrest and Automated External Defibrillators (AEDs)* (TIB 01-12-17) (Washington, DC: U.S. Department of Labor), accessed October 29, 2014, https://www.osha.gov/dts/tib/tib_data/tib20011217.pdf.

[14] International Association of Fire Fighters (IAFF), E*mergency Medical Services: A Guidebook for Fire-Based Systems*, 4th ed. (Washington, DC: IAFF), 13.

combined 14 people suffered cardiac arrest at the two airports. Of the 14 cardiac arrest victims, however, 64 percent (9 of the 14) survived.[15] In 2002, Congress passed the Community Access to Emergency Devices Act. This legislation enabled grant funding for state and local jurisdictions to purchase AEDs for placement in public places.[16] Today, many public locations have a public access AED available for use.

While studies support that early CPR and AED application saves lives, studies also reaffirm the importance of quick use and highlight a need for increased training and awareness in both CPR and AED. One study, which examined the effect of a media campaign on CPR survival, revealed a link between increasing awareness and increasing bystander participation.[17] This could mean that a campaign involving traditional and social media may provide an effective strategy to encourage more people to receive CPR training and promote bystander participation. Community programs that encompass CPR and AED training for bystanders have been shown to produce improved survival for victims of cardiac arrest.[18]

4.   Response Times

National Fire Protection Association (NFPA) 1710 is the consensus standard followed for response times.[19] In 2001, the first edition of NFPA 1710 was published, titled *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*.[20] This 2001 document marked the first structured approach to setting the

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[15] OSHA, *Cardiac Arrest and Automated External Defibrillators*.

[16] IAFF, E*mergency Medical Services*, 13.

[17] Anne Moller Nielsen, Dan Lou Isbye, Freddy Knudsen Lippert, and Lars Rasmussen," Can Mass Education and a Television Campaign Change the Attitudes towards Cardiopulmonary Resuscitation in a Rural Community?" *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 21, no. 39 (May 2013), doi 10.1186/1757-7241-21-39.

[18] Nielsen et al., "Can Mass Education and a Television Campaign Change Attitudes."

[19] IAFF, E*mergency Medical Services*, 49.

[20] Newest edition published for 2016. See National Fire Protection Association (NFPA), *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, 2016 edition (NFPA 1710) (Quincy, MA: NFPA, 2015), 1710-01.

service levels, deployment capabilities, and staffing levels for career departments.[21] The 2016 edition of NFPA 1710 is the most up-to-date version of this standard.

Because it outlines the criteria for response time for both structural fires and EMS response, NFPA 1710 is also the standard by which career fire-based EMS systems, such as NYC, are judged for response time compliance.[22] The standard calls for the alarm processing by the dispatcher to be completed in less than 64 seconds and for responders to be out the door for medical calls less than one minute following dispatch.[23] For travel time to the location of the call, the standard allows for a

> 240 second or less travel time for the arrival of a unit with first responder with AED or higher capability at an emergency medical incident and 480 seconds or less travel time for the arrival of an advanced life support (ALS) unit at an emergency medical incident, where this service is provided by the fire department provided a first responder with AED or basic life support (BLS) unit arrived in 240 seconds or less travel time.[24]

To be in compliance with NFPA 1710, these response times must be attained at least 90 percent of the time.[25]

The standard for response times to a structural fire is more stringent than for medical emergencies, with more units required to arrive on the scene in a similar timeframe.[26] Fire departments meeting the standard for structural fires will naturally meet this standard for EMS responses if staffed with medically qualified personnel. Meeting the response criteria of NFPA 1710 alone, however, does not equal optimum survival for victims of cardiac arrest. For cardiac arrest victims, the clock starts when they stop breathing and ends when CPR is initiated and an AED is applied. It is likely that, by the time emergency responders are notified, dispatched, arrive, and begin CPR, many critical minutes will have passed.

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[21] NFPA, *Standard for the Organization and Deployment of Fire Suppression Operations*, 1710-01.

[22] Ibid., 1710-08.

[23] Ibid.

[24] Ibid., 1710-09.

[25] Ibid.

[26] Ibid., 1710-08.

5. Desire to Help

There are many documented cases of strangers helping one another in times of great need. In his position as a battalion chief with the New York City Fire Department (FDNY), the researcher has often witnessed such caring and compassion—at the scene of a car accident where bystanders stop to help the injured, or when strangers place their own safety in jeopardy to remove residents from a burning building. A recent example can be seen in the response after the detonation of two improvised explosive devices near the Boston Marathon finish line in April 2013; many people rushed to the blast site in an effort to assist those in need.

As highlighted in a Harvard paper titled *Why Was Boston Strong*, one response track that was triggered by the explosions was "the community-caring response…Almost instantaneously, survivors, bystanders and on-scene first responders rushed to the aid of the injured."[27] Many civilians who rushed to the blast site had some type of medical training and undoubtedly saved many lives.[28] The term "Boston Strong" arose out of the Boston people's sense of pride and resilience, and stands as a shining example of instinct, human spirit, and desire to help another person when help is needed most.

The actions displayed in Boston provide one example of bystanders' willingness to help during an emergency. As demonstrated, facilitating those willing to help to collectively save lives is critical for victims of cardiac arrest. The need for bystander CPR is unmistakable, as "for most EMS systems, arriving in less than four minutes at the side of a patient whose arrest resulted in a 911 call is nearly impossible."[29]

CPR and defibrillation within the first four minutes of cardiac arrest to bridge the gap until first responders arrive increases survival. Additionally, much of the effective action for OHCA cases hinges on the readiness and willingness of bystanders to render aid. The term "shifting the curve" was used to describe the results of a study that

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[27] Herman B. "Dutch" Leonard et al., Why *Was Boston Strong? Lessons from the Boston Marathon Bombing* (Cambridge, MA: Harvard Kennedy School, 2004), 7.

[28] Leonard et al., Why *Was Boston Strong?*, 8.

[29] Freese, "Shifting the Curve."

measured the success from changes in responder policy.[30] The goal of this thesis is to further shift that curve using bystander CPR.

B. LITERATURE REVIEW

To increase bystander participation, it is important to understand bystander motivation to perform CPR. Conversely, it is important to understand the environment, human behavior, and other factors that prevent the bystander from participating. It is also significant to understand how modern bystanders connect to the world around them, specifically considering technology that may be useful to facilitate the bystander to perform CPR.

1. Socio-Technical Systems Theory

New York City is a socio-technical system; there is a relationship between the system of cardiac response (first responders and bystanders) and the related systems that must interact with each other—systems of buildings, infrastructure, and technology. As such, recommendations should be evaluated considering socio-technical systems (STS) theory. STS theory involves looking at a system from both the social and technical sides to evaluate problems and the synergistic relationships that are developed—it means investing "in predictive work that helps identify potential problems and solutions in advance."[31] The designer must think of how the different individual parts will interact as a system. Many factors can affect the system, such as laws, regulations and culture, and technology.

The origin of STS theory dates to 1949 with a study of the British coal mining industry after the introduction of new coal mining machinery.[32] After the new machinery failed to increase production, studies examined the organizational social system and the technical system combined with the social system, and the new field of inquiry was

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[30] Ibid.

[31] Matthew C. Davis et al., "Advancing Socio-Technical Systems Thinking: A Call for Bravery," *Applied Ergonomics* 45, no. 2 (2014): 178, doi 10.1016/j.apergo.2013.02.009.

[32] Davis et al., "Advanced Socio-Technical Systems Thinking," 171.

begun.[33] Research generally agrees about the value and importance of evaluating complex systems using STS theory.[34] Additionally, "most contemporary problems in society are, at least in part, systemic in their origins and will often require systemic analyzes and solutions."[35] Understanding the individual parts is insufficient; the entire system must be evaluated.

System evaluation using STS theory clarifies the interaction of people, the environment, laws, perceptions, culture and technology when combined to create a complex system designed to increase bystander CPR (see Figure 4). An example of evaluation using STS theory would be recommending implementation of a pulse point for notifying bystanders about the need to help. This recommendation must be considered in the context of the systems with which it will interact to predict and prevent unintended consequences. In this example, some possible considerations might be: Will the pulse point function as intended inside buildings? What impact will it have on first responder policies? How will this technology integrate with the dispatch infrastructure? Once all of the possible interactions with other systems are addressed, the recommendation can be implemented.

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[33] Ibid., 172.

[34] Ibid.

[35] Ibid., 178.

Figure 4.   The Interrelated Nature of an Organizational System Environment
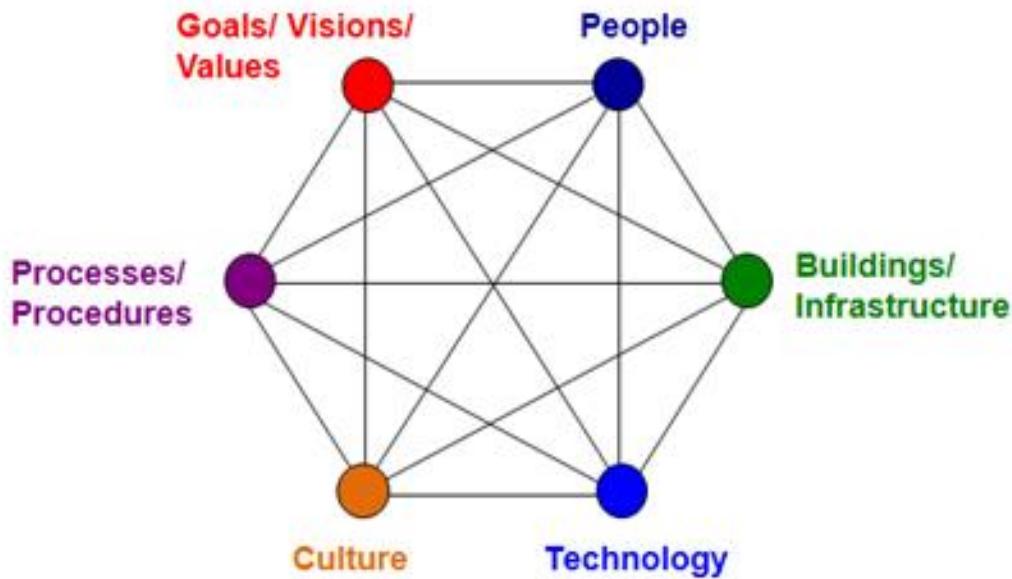
Adapted from Matthew C. Davis et al., "Advancing Socio-Technical Systems Thinking: A Call for Bravery," *Applied Ergonomics* 45, no. 2 (2014): 171–180, doi 10.1016/j.apergo.2013.02.009.

2.   Civic Engagement

By examining human behavior, this section studies how the bystander effect and group dynamics pose barriers to increasing bystander CPR. Furthermore, it is essential to consider modern communities where technology has become ubiquitous in daily life. This section examines crowdsourcing, the modern bystander, and the modern community.

a.   *Crowdsourcing and the Online Community*

One modern model through which to facilitate and increase bystander participation may be crowdsourcing. Coined in 2006 by Jeff Howe in a *Wired* Magazine article, the term typically was used to discuss or describe a business plan that harnesses the power of the online community.[36] According to Daren Branham of MIT, "crowdsourcing is an on-line, distributed problem solving and production model that

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[36] Jeff Howe, "The Rise of Crowdsourcing," *Wired*, June 1, 2006, http://www.wired.com/2006/06/crowds.

leverages the collective intelligence of online communities for specific purposes set forth by a crowdsourcing organization—corporate, government, or volunteer."[37]

Crowdsourcing, for the purposes of this thesis, is the principle of using the crowd (the bystanders) to engage and perform a function or task (CPR) that traditionally was thought of as the exclusive responsibility of first responders. It is about leveraging people, referred to as the crowd—specifically those people connected online by using a smart phone. Crowdsourcing in this sense refers to notifying the online community that help is needed, then actively participating and contributing to a solution by performing CPR prior to the arrival of first responders.

While much of the early literature related to crowdsourcing discussed the topic from a business standpoint, more recent research now also focuses on self-organizing volunteers, motivations and ways people volunteer, and the desire to create something that benefits the entire community. This paradigm shift has been driven by desires to understand civic engagement for political and social benefit. Putnam, his book *Bowling Alone*, claims that community engagement has been on the decline in the past half century.[38] However, Howe, in his more recent book, *Crowdsourcing: Why the Power of the Crowd Is Driving the Future of Business*, argues the contrary: that, due to the Internet and technology, communities are reforming and becoming local, vibrant, and wired.[39] In other words, even if community-mindedness had been declining, crowdsourcing and technology may be reversing this trend by facilitating online communities that enable the public to engage like never before.

Still, municipalities have yet to fully utilize the power of crowdsourcing and the tremendous possibilities that it holds for increasing civic engagement for public good. While it is not clear if business models of crowdsourcing can be successfully integrated into society to increase bystander participation to save the lives of those in cardiac arrest,

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[37] Daren Brabham, *Crowdsourcing* (Cambridge, MA: MIT Press, 2013), 117.

[38] Robert Putnam, *Bowling Alone: The Collapse and Revival of American Community* (New York: Simon & Schuster, 1990).

[39] Jeff Howe, *Crowdsourcing: Why the Power of the Crowd Is Driving the Future of Business* (New York: Crown, 2008).

we know through research that harnessing the power of the crowd and the vibrant online community that already exists through crowdsourcing may be a key factor in increasing bystander participation.

b.   *Understanding the Modern Bystander*

Gordon, Baldwin-Philippi, and Balestra, in *Why We Engage, How Theories of Human Behavior Contribute to Our Understanding of Civic Engagement in a Digital Era* present a study of civic engagement to understand emerging media and its effect on civic life and engagement.[40] As explained previously, the online community is vibrant, wired, and engaged, and may provide a pathway to increasing bystander participation. However, understanding this modern bystander and how technology in the digital era is "changing civic life may necessitate a change in the way technology is used, evaluated and understood for increasing bystander engagement."[41] The authors suggest that the evolving landscape of connectivity and communications technologies is changing how civic life—specifically how civic engagement—is changing based on these emerging media tools.[42] These "tools" can be divided into two broad categories, those with a purpose of community engagement in mind and those designed for engaging the community.[43] These tools can be used to increase bystander engagement, possibly in the form of a smartphone app that connects a user to a person needing help, the location of an AED, or simply an app that teaches CPR. Additionally, the authors state that an increasing number of users are interacting in various and greater ways than ever before. Due to device portability, users are able to interact with information in new physical locations. Furthermore, connectivity and communication technology is changing how people participate in civic life. New technologies and social practices provide different ways to record and share, and in the process, amplify attentiveness. New technologies are

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[40] Eric Gordon, Jesse Baldwin-Philippi, and Martina Balestra, *Why We Engage: How Theories of Human Behavior Contribute to Our Understanding of Civic Engagement in a Digital Era* (Research Publication No. 2013-21) (Cambridge, MA: Harvard, October 2013), 18.

[41] Gordon, Baldwin-Philippi, and Balestra, *Why We Engage*, 2.

[42] Ibid.

[43] Ibid.

impacting the context in which bystanders can take action in the shifting landscape for participation.[44]

In *Understanding America's Interested Bystander: A Complicated Relationship with Civic Duty*, Kate Krontiris, John Webb, Charlotte Krontiris, and Chris Chapman conclude that 48 percent of the public can be considered interested bystanders—that is, the group of people who are aware of what is going on in their communities but usually remain quiet, not expressing their views or becoming involved.[45] Their work highlights both positive and negative factors that affect civic engagement and breaks them down into groups along the spectrum of civic engagement. From most to least civically engaged, the groups are named "Community Active," "Neighborhood Advocates," "Vocal Opinionators," "Issues Aware," "The Absentees," and "Civically Disconnected."[46] Importantly, they identify motivations for taking action and what gets people over the activation threshold to increasing civic engagement.[47]

Together, these reports indicate the degree of bystanders' willingness to be engaged. Further, they identify categories of engagement and offer factors that affect placement along the civic engagement spectrum. Also revealed, however, is the degree of engagement, and that engagement can be facilitated by advances in technology.

c. *Diffusion of Responsibility—The Bystander Effect*

In 1964, Nurse Kitty Genovese was returning to her apartment in Queens, New York, late at night when she was attacked by a man with a knife. During the brutal attack, the young woman continuously called out for help. When someone finally did notify the police, some 35 minutes had already passed. The police investigation revealed that 38 people had witnessed the attack, but only one eventually called the police.[48] Following

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[44] Ibid., 8.

[45] Kate Krontiris, John Webb, and Chris Chapman, *Understanding America's Interested Bystander: A Complicated Relationship with Civic Duty* (Mountain View, CA: Google, 2015), 54.

[46] Krontiris, Webb, and Chapman, *Understanding America's Interested Bystander*, 54.

[47] Ibid., 20.

[48] Ibid.

this tragedy, people wondered why so many otherwise decent people—Kitty Genovese's neighbors—failed to act.

According to Darley and Latane, bystanders go through a thinking process prior to taking action (see Figure 5).[49] These steps provide insight into the process of bystander engagement that are similar in some regard to the five-step Chain of Survival.

Figure 5.   Five-Step Bystander Thinking Process
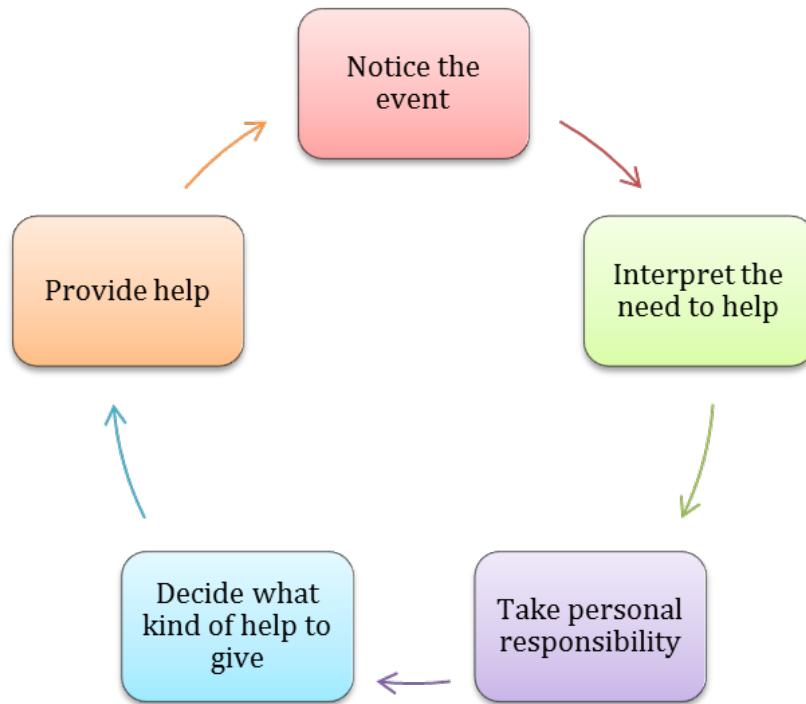
Adapted from: Bibb Latane and John M. Darley, "Group Inhibition of Bystander Intervention in Emergencies," *Journal of Personality and Social Psychology* 10, no. 3 (November 1968): 215–221, http://spmoodle23.aisgz.org/pluginfile.php/56664/mod _resource/content/0/Latane%20%20Darley%201968%20-%20Smoke.pdf.

It would be natural to assume that the more bystanders there are in an emergency, the greater the likelihood of bystander engagement. However, research has shown that this may not be the case. Darley and Latane refer to this phenomenon as the diffusion of

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[49] Bibb Latane and John M. Darley, "Group Inhibition of Bystander Intervention in Emergencies," *Journal of Personality and Social Psychology* 10, no. 3 (November 1968): 215–221, http://spmoodle23.aisgz.org/pluginfile.php/56664/mod_resource/content/0/Latane%20%20Darley%201968 %20-%20Smoke.pdf.

responsibility.[50] "If an individual is alone when he notices an emergency, he is solely responsible for coping with it. If he believes others are also present, he may feel that his own responsibility for taking action is lessened, making him less likely to help."[51] In a crowd, it is possible that no one will take responsibility for action, believing that others will, resulting in inaction on the part of the group.[52] Each individual may agree that something ought to be done, but each also assumes that another group member has taken action. This situation is collectively known as the bystander effect. There is one important exception: in cases where special expertise is needed (such as CPR certification), a person will take action even when part of a group of bystanders.[53]

Similarly, in a *Journal of Personality and Social Psychology* article titled "Crowded Minds: The Implicit Bystander Effect," the authors found that people who viewed themselves as part of a crowd were less inclined to assist than those who had thought themselves alone.[54] However, in a study published in the Journal of Experimental Social Psychology, researchers studied the role of public self-awareness in bystander non-intervention.[55] Their research concluded that in situations where accountability cues are employed, and people think that someone is watching (such as in an area monitored by public cameras), the bystander effect was reversed, even when a crowd was present.[56]

d.   Group Dynamics

As reported in *Personality and Social Psychology Bulletin*, two British experiments studied the effects of social group membership and group boundaries, and

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[50] Latane and Darley, "Group Inhibition of Bystander Intervention in Emergencies."

[51] Ibid.

[52] Ibid., 342.

[53] Ibid., 344.

[54] Stephen M. Garcia, et al., "Crowded Minds: The Implicit Bystander Effect," *Journal of Personality and Social Psychology* 83, no. 4 (2002): 852, doi 10.1037/0022-3514.83.4.843.

[55] Marco van Bommel et al., "Be Aware to Care: Public Self-Awareness Leads to a Reversal of the Bystander Effect," *Journal of Experimental Psychology* 48, no. 4 (July 2012): 926–930), doi 10.1016/j.jesp.2012.02.011.

[56] Van Bommel et al., "Be Aware to Care."

their effect on helping those in need.[57] The research suggests that bystanders are inclined to assist a person in need of help when that person is part of a common group to which they both belong.[58] However, what defines group membership is variable and can be altered.[59] When encouraged to see greater commonalities with strangers, bystanders are more likely to offer assistance to someone whom they may have otherwise considered part of the "out group."[60] This dynamic was demonstrated during the two studies by changing the perception of the "in group" to increase bystander engagement. Together, these studies demonstrate the significance of a mutual identity between bystander and victim and the connection to the likelihood of bystander intervention. In addition, as Stanford Professor Francis Flynn points out, the results indicate that when bystanders are able to expand social category boundaries to be more inclusive, they are likely to extend help to more individuals.[61] These methods of manipulating the population to increase group membership could lead to increased bystander CPR and can have a profound impact on related policy recommendations.

e.   Barriers in the Urban Environment

Robert Cialdini, a noted expert in the science of persuasion, states in *Influence: The Psychology of Persuasion* that there are six basic categories that direct human behavior, each governed by a fundamental psychological principle: reciprocation, consistency, social proof, liking, authority, and scarcity.[62] Knowledge of these "weapons of influence," as Cialdini refers to them, can lend insight to why bystander intervention so often does not take place and, more importantly, how this trend can be reversed. As

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[57] Mark Levine et al., "Identity and Emergency Intervention: How Social Group Membership and Inclusiveness of Group Boundaries Shape Helping Behavior," *Personality and Social Psychology Bulletin* 31, no. 4 (April 2005): 443–53.

[58] Levine et al., "Identity and Emergency Intervention."

[59] Ibid.

60 Ibid.

[61] Francis Flynn, "What Makes People Want to Help Others?" *Insights by Stanford Business*, November 21, 2013, https://www.gsb.stanford.edu/insights/francis-flynn-what-makes-people-want-help-others.

[62] Robert B. Cialdini, *Influence: The Psychology of Persuasion* (New York: Harper Collins, 2007).

shown in Figure 6, Cialdini posits that there are three natural characteristics of urban environments that may contribute to low levels of bystander participation.[63]

Figure 6.   Cialdini's Urban Environment Barriers to Bystander Participation

Potential barriers to increasing civic engagement in urban environments

Urban environments are often rapidly changing and can be confusing and difficult to decipher when an emergency exists	Urban environments tend to be more densely populated than rural areas and thus due to a larger number of people there is an increased likelihood of a group of people witnessing an emergency	Urban city dwellers know a smaller percentage of their neighbors and are therefore more likely to witness an emergency in the company of strangers

Adapted from: Robert B. Cialdini, *Influence: The Psychology of Persuasion* (New York: Harper Collins, 2007).

Urban environments are often rapidly changing and can be confusing and difficult to decipher in an emergency. This confusion often leads to inaction on the part of the bystander.[64] Additionally, city dwellers know fewer neighbors than their rural counterparts and are therefore more likely to witness an emergency in the company of strangers.[65] Because people are more likely to help when they have a connection to the victim, the urban environment—in which you may not know your neighbor—presents an additional barrier.

The key to understanding and eliminating certain barriers is the dynamics of how these weapons of influence, the power of persuasion, and subtle "nudges" can be used to

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[63] Cialdini, *Influence*, 136.

[64] Ibid.

[65] Ibid.

benefit victims of cardiac arrest. It is equally important to understanding barriers that are present in urban environments that may impede bystander CPR. Recommendations can be considered that eliminate these urban barriers and therefore increase bystander CPR.

f.   Defining the Emergency

In an example, Cialdini demonstrates the importance of defining the emergency and ensuring that others are put in the role of the "rescuer."[66] He writes: "The trick is to get the ball rolling in the direction of aid."[67] One way to do this is to point at a specific person and tell them to call an ambulance. You must not allow the bystanders to define your situation as non-emergency.[68] Not surprisingly, this is similar to a method used in CPR training, in which a bystander performing CPR points at another bystander and instructs him or her to call 911 (see Figure 7). This provides one example of how psychology can and has been used to overcome one of the barriers to increase bystander participation and save lives. Technology modeling this method can be adapted to devise a notification system that specifies a person to help, thereby defining the emergency and getting the ball rolling in the direction of aid.

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[66] Cialdini, *Influence*, 138.

[67] Ibid., 140.

[68] Ibid., 137

Figure 7.   CPR Poster—Assigning a Specific Person to Help

One of the many posters available for purchase that depicts the steps of CPR, including assigning someone to call 911. Source: "CPR for Adults Chart/Poster," AnatomyStuff, accessed February 10, 2016, http://www.anatomystuff.co.uk/product-cpr-for-adults-chart-poster_71292.aspx.

3.   Good Samaritans and the Law

Good Samaritan laws are written to protect those willing to help. They vary from state to state, and understanding them is no easy task. Often, these laws contain vague definitions, which can lead to gray areas of afforded protection and perpetuate beliefs that protections are inadequate. In New York, Article 30 of the New York State Public Health Law defines the protections to Good Samaritans.[69]

Potential Good Samaritans, such as doctors and other professionals, may be hesitant to help for fear of being sued. Legal cases involving Good Samaritans are often sensationalized by the media and widely covered; these stories live in the human consciousness and may have a long-lasting impact. Daniel Kahneman describes this best when discussing the illusions of truth in his book *Thinking Fast and Slow*: "a reliable way to make people believe in falsehoods is frequent repetition, because familiarity is not easily distinguished from the truth."[70] Even when these cases are dismissed or lost, the public falsehood remains that Good Samaritan laws may not provide adequate protection against litigation. As noted by Jeffrey Klein in a piece for the *Los Angeles Times*,

> Once you start to help, you have a legal duty to exercise due care in the performance of your assistance. The law does not generally punish nonfeasance—doing nothing—it only punishes malfeasance—doing something, but doing it wrong. So you will be liable for any bodily harm that arises from your failure to exercise due care. You also will be legally accountable if you discontinue the aid and leave the injured party in a worse position than when you found him.[71]

Usually, a bystander has no legal duty to act. In fact, the California Supreme Court once explained: "A person who has not created a peril is not liable in tort merely for failure to take affirmative action to assist or protect another unless there is some relationship between them which gives rise to a duty to act."[72] These special

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[69] "Public Health Law Article 30," New York State Department of Health, last modified February 3, 2009, https://www.health.ny.gov/professionals/ems/art30.htm.

[70] Daniel Kahneman, *Thinking Fast and Slow* (New York: Farrar, Straus and Giroux, 2013), 62.

[71] Jeffrey Klein, "Drawbacks to Being a Good Samaritan," *Los Angeles Times*, September 19. 1985, http://articles.latimes.com/1985-09-19/news/vw-2058_1_emergency-care.

[72] Klein, "Drawbacks."

circumstances exist in such cases as a teacher and a student, a guard and a prisoner, a babysitter and the child, etc. Absent of a special circumstance, however, bystanders have no obligation to help those in need.

Some have argued that the United States should, like France, insist that there be legal consequences for bystander inaction.[73] Others, however, think individual decision-making must be maintained. Stating that you can't legislate goodwill, Sheldon Richman argues that "the American philosophy of jurisprudence doesn't permit the government to impose positive obligations on citizens…thus, even if you believe that morality requires you to help an accident victim, it's not enforceable by government."[74] In a comparative law review for Loyola Marymount Law School, John Pardun concluded that emulating the French Good Samaritan laws is untenable, based primarily on the distinctions between two prevailing derivations of law, common law and civil law.[75] Pardun concludes that Good Samaritan statutes in the United States have not been effective and cites Minnesota, Wisconsin, and Vermont as examples of states that have codified Good Samaritan statutes, all of which have seldom been used or upheld.[76] Further bolstering Pardon's position, a Minnesota bill that he sponsored was considered primarily symbolic, representative of Minnesota's vision of a model society.[77]

While arguments are made both for and against duty-to-act laws, it is evident that in the United States and other common law jurisdictions that these laws, when enacted, are rarely enforced and are thus ineffective. Issues such as cost and the possibility that Good Samaritans can become prey for unscrupulous people targeting those required to help create additional considerations.[78]

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[73] Alldred, Gloria, and Lisa Bloom. "We All Have a Duty to Help One Another," *Los Angeles Times*, September 14, 1997, http://articles.latimes.com/1997/sep/14/opinion/op-32203.

[74] Sheldon Richman, "You Can't Legislate Goodwill," *Christian Science Monitor*, October 22, 1997, http://www.csmonitor.com/1997/1002/100297.opin.opin.2.html.

[75] John T. Pardun, "Good Samaritan Laws: A Global Perspective," *Loyola Los Angeles International and Comparative Law Review* 20, no. 3 (1998): 591–613, http://digitalcommons.lmu.edu/ilr/vol20/iss3/8.

[76] Pardun, "Good Samaritan Laws."

[77] Ibid., 606.

[78] Ibid.

C.   METHODOLOGY

This thesis research evaluated policies, people, and technology by assessing programs, policy initiatives, laws, and the system in which they interact. This identified examples that provided the foundation for recommendations. The recommendations were analyzed using the researcher's framework for analysis. By comparing and contrasting the successes and failures of the examples, the researcher analyzed what worked, what failed, why, and how, and then applied the scenarios to New York City, considering its unique issues.

The framework of analysis consisted of the following steps:

1.   Identified and defined the problem of OHCA

2.   Conducted research on OHCA and identified survival rates as a key metric of evaluation

3.   Conducted research on survival rates of OHCA, identifying programs, policy initiatives, and laws that contributed to high survival rates of OHCA

4.   Examined data to determine how and why successes were achieved:

- Identified implemented changes

- Identified bystanders as a pathway to increasing survival

- Identified context, barriers, and survival rates at different intervals

- Identified factors that may influence outcomes

5.   Conducted additional research on background and literature review topics

6.   Identified projected or actual outcomes of possible solutions, which were then measured against evaluation criteria for success

7.   Selected best solutions for recommendations and then adapted successes into recommendations for NYC

8.   Identified and reported key findings, takeaways, and conclusions

9.   Reported recommendations for NYC

To answer the research question, the researcher identified increasing bystander CPR as the pathway to increasing survival from OHCA. Recommendations were synthesized that encourage and support increased bystander CPR.

(1)   Data Sources and Study Selection

The data sources used for this thesis were from select research reports, medical publications, and internal memos. Initiatives, policies, or ideas that influenced civic engagement were evaluated based on increased bystander engagement. Those that met the criteria were selected and included in this thesis. This process involved analyzing and synthesizing the similarities and differences across the selected examples used to examine the causality of the policies and programs for increasing bystander engagement.

(2)   Evaluation Criteria

To evaluate the influence of bystander CPR on the examples used in this thesis, the researcher used the percentage of bystanders who performed CPR and survival rates from cardiac arrest. The researcher decided on this criterion because studies demonstrate that bystander CPR rates have a correlation to increasing survival from cardiac arrest. Additionally, since increasing survival rates is the ultimate goal of this thesis, it is an obvious criterion of evaluation.

(3)   Limitations

The American Heart Association states that "a strong Chain of Survival can improve chances of survival and recovery for victims of heart attack, stroke and other emergencies."[79] The time frame of reference for this thesis is during the first three (of five) steps in the Chain of Survival, which is from the time a person stops breathing (cardiac arrest) until patient care is transferred to first responders. The fourth and fifth steps, "effective advanced life support and integrated post cardiac care," while important, are not addressed in this thesis, as these steps occur after first responders arrive.[80]

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[79] American Heart Association, "Out-of-Hospital Chain of Survival."

[80] Ibid.

Only out-of-hospital cardiac arrests are part of this research, since cardiac arrests that occur in hospitals often receive quick medical attention. The researcher also identified the percentage of CPR-trained members of the community as critical evaluation criteria, but these measurements are not widely available (obtaining this measurement is incorporated into the recommendations of this thesis). Additionally, this researcher did not study first responder staffing, or causes that lead to cardiac arrest.

D.   CHAPTER OVERVIEW

The thesis unfolds in the following sequence of chapters: Chapter II provides an overview of the emergency response system and the results of studies involving NYC, and identifies both the current challenges to the system as well as challenges that may be on the horizon. Chapter III reviews implemented policies that have led to increased bystander participation and increased survival from cardiac arrest. Policies that require emergency medical-trained dispatchers, CPR in school, and partnerships are evaluated. Chapter IV gives an overview of the training and tiered response of first responders, and examines the role of the bystander, barriers, and hands-only CPR as a way to eliminate barriers.

Today's technology may hold solutions that can transform the way people interact with society to facilitate a response to calls for help. Chapter V is divided into two sections. The first section describes technologies that may be adapted and used to facilitate bystander CPR. The second section focuses on technology, specifically smartphone apps, that can be used or adapted to locate victims and encourage bystander CPR.

E.   SIGNIFICANCE OF THE RESEARCH

This research intends to help reduce needless deaths associated with OHCA. Reducing the gap between the time a person stops breathing until CPR and AED application is relevant to homeland security because of the high mortality rate associated with OHCA. This research also has a personal significance to the researcher, as his brother, Bobby, passed away after suffering out-of-hospital cardiac arrest. Bobby was 36 years old and had been working an early-morning shift, making deliveries, when he

suffered sudden cardiac arrest. A bystander noticed him slumped over in his vehicle and called 911. Although the bystander initiated a call for help, like so many others, this bystander failed to become involved and did not perform the lifesaving function of CPR. When the ambulance arrived, the crew quickly began CPR in an attempt to restore a heartbeat. They valiantly continued to perform CPR and transported him to the hospital, where he died a short time later. One purpose of this thesis is to prevent our citizens from losing loved ones when lifesaving options are available.

II.   NEW YORK CITY

The goal of this thesis is to develop a set of recommendations to improve survival from out-of-hospital cardiac arrest in NYC. Before recommendations can be proposed, however, the emergency response system and the results of studies involving NYC must be evaluated. This chapter provides an overview of NYC's system and its complexities to identify both current challenges to the emergency response system and challenges that may be on the horizon.

NYC is a large urban area that covers 322 square miles and comprises five geographic-defined boroughs.[81] With a 2014 population of 8,405,837, NYC is the largest city in the United States.[82] According to the FDNY 2014 vital statistics report, the department is comprised of 218 firehouses and 37 EMS stations.[83] The EMS division consists of 3,706 uniformed personnel, while the fire branch consists of 10,728 uniformed personnel.[84]

In 2015, the FDNY (fire and EMS) responded to a record 1,747,345 calls for assistance (see Figure 8).[85] This total is an increase of 6.4 percent from 2014.[86] The fire unit responded to 581,982 emergency calls, of which 269,951 were for medical emergencies.[87] EMS units responded to 1,670,628 calls, with responses to life-threatening issues (cardiac arrest, choking, unconsciousness) comprising 566,210 responses, up 17 percent from 2014.[88]

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[81] "FDNY Vital Statistics: Calendar Year 2014," FDNY, accessed February 13, 2016, http://www.nyc.gov/html/fdny/pdf/vital_stats_2014_cy.pdf.

[82] "FDNY Vital Statistics: Calendar Year 2014," FDNY.

[83] Ibid.

[84] Ibid.

[85] "Mayor De Blasio and Fire Commissioner Nigro Announce 17 Percent Decline in Fire Deaths in 2015," FDNY, January 8, 2016, http://www.nyc.gov/html/fdny/html/events/2016/010816a.shtml.

[86] "Mayor De Blasio," FDNY.

[87] Ibid.

[88] Ibid.

Figure 8.   FDNY Five-Year Response Trend (Fire and EMS)

A.   CARDIAC ARREST SURVIVAL AND THE FDNY

From October 1990 to April 1991, a six-month evaluation of cardiac arrest survival was conducted in New York City.[89] One of the first studies of its kind, it was named the Prehospital Arrest Survival Evaluation (PHASE) study. The results of this study, as reported by John Freese in an FDNY periodical, demonstrated very low survival rates. Overall survival rates were 2.2 percent when resuscitation was attempted in the pre-hospital setting, and dropped to 1.4 percent for arrests that occurred prior to the arrival of EMS. The group most likely to survive was victims with bystander-witnessed cardiac arrests, in which the victims had a shockable rhythm upon the arrival of EMS—this group of victims had a survival rate of 5.3 percent. According the report, bystanders performed CPR 36.5 percent of the time. Additionally, the return of spontaneous circulation (ROSC)—the criteria used to define a successful resuscitation, which includes

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[89] Freese, "Shifting the Curve."

coughing, breathing, or a palpable pulse—rate was 28.2 percent.[90] During the time of the study, the average EMS response time to a cardiac arrest was 9.3 minutes.

In 1996, the FDNY and EMS merged, forming the largest fire-based EMS service in the country.[91] Between 2002 and 2003, a year-long repeat of the PHASE study was conducted. Named the Prehospital Evaluation of New York City Survival (PHENYCS) study, the aim of this study—again according to Freese, writing for the FDNY—was to reassess cardiac arrest survival following the merger of the FDNY and EMS.[92] Following the merger, the combined department trained firefighters as first responders and implemented a first responder program. This measure added 210 fire engines as defibrillation-capable units.[93] Additionally, according to Freese, the department added ambulance tours, nearly doubling the number of ambulances available for a response. The findings of this study demonstrated across-the-board increases in survival and revealed a drop in the average response time from 9.3 minutes to 4.6 minutes. [94] Overall survival rates went from 2.2 percent to 2.9 percent when resuscitation was attempted in the pre-hospital setting.[95] Survival rates among only arrests that occurred prior to the arrival of EMS went from 1.4 percent to 2.5 percent, and the group most likely to survive (a victim with a bystander-witnessed cardiac arrest) went from 5.3 percent to 9.3 percent.[96] Bystander CPR rates went from 36.5 percent to 32.6 percent.[97]

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[90] "ROSC is the signs of the return of spontaneous circulation and includes breathing (more than an occasional gasp), coughing, or movement. For healthcare personnel, signs of ROSC also may include evidence of a palpable pulse or a measurable blood pressure. ROSC is defined as 'successful resuscitation' or ROSC is defined for all rhythms as the restoration of a spontaneous perfusing rhythm that results in more than an occasional gasp, fleeting palpated pulse, or arterial waveform." Richard Cummins et al., "Recommended Guidelines for Reviewing, Reporting, and Conducting Research on In-Hospital Resuscitation: The In-Hospital 'Utstein Style,'" *Circulation* 95 (1997): 2213–2239, doi 10.1161/01.CIR.95.8.2213.

[91] "History and Heritage/EMS," FDNY, accessed February 12, 2016, http://www.nyc.gov/html/fdny/html/history/ems_article.shtml.

[92] Freese, "Shifting the Curve."

[93] Ibid.

[94] Ibid.

[95] Ibid.

[96] Ibid.

[97] Ibid.

The increase in survival and decrease in response time observed in the PHENYCS study demonstrates the importance of a timely response to calls for help. These statistics also indicate the positive effect additional ambulance tours and defibrillation-equipped, CPR-trained units can have on response time and survival. However, while the data indicated improvements, it also revealed the continuation of less-than-optimal survival rates from OHCA, and that the system still has difficulty reaching cardiac arrest patients in time.

The department, motivated to improve cardiac arrest survival rates, implemented a sequence of changes. In 2004, four years before the American Heart Association's adoption and campaign for "hands-only CPR," the FDNY introduced compression-only CPR instructions. These instructions were given to 911 callers who were not trained in CPR. In 2005, the FDNY created the FDNY CPR training unit to offer free hands-only CPR training to schools and community organizations. In 2006 and 2007, the FDNY incorporated additional changes (unrelated to this study) that emphasized quality improvement and control in the delivery of first responder care.

In order to assess the effect of these changes on cardiac arrest survival, the FDNY evaluated six months of compiled data (November of 2007 to April 2008) and compared the data to the two previous studies, PHASE and PHENYCS. The results of this data analysis were mixed. Specifically, the data revealed no change in response times, a reduction in shockable rhythms (likely due to effective medical management of coronary disease and the use of implanted defibrillators), and an improvement in ROSC over the previous studies (up to 33.9 percent from a previous low of 20.2 percent).[98] The data indicates an improved system with mixed results. Significant increases in ROSC were reported and bystander CPR rates saw a modest increase to 33.8 percent. This is likely due to the numerous positive changes the department initiated. Although the study indicated consistency, there was no further improvement in response time observed during this study.

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[98] Ibid.

A three-year study that analyzed the data from August 2009 to July 2012 confirmed the continued upward trend in survival rates in witnessed cardiac arrests.[99] The report also indicated improvements were observed in all survival endpoints. Notably, the report emphasized the increase in ROSC, from 20.2 in the PHENYCS study to 38.5 percent in this study.[100] This report demonstrates the increasing percentage of patients who are surviving due to the changes implemented since the PHASE study. While evaluating response time was not part of this study, the most recent data available reveals that the average response time in 2014 for a first responder from the fire division was 4 minutes and 23 seconds, while the average EMS division response to a life-threatening emergency was 6 minutes and 50 seconds.[101] The combined average time to arrive at life threatening emergencies for the fire and EMS divisions combined was 5 minutes and 53 seconds.[102]

Additionally, an examination of the vital statistic data from 2012 to 2014 confirms that the response times have remained consistent in the past several years.[103] These average response times are above the NFPA 1710 standard (introduced in Chapter I of this thesis). However, FDNY response times have improved significantly as compared to the original PHASE study conducted in 1994 and are consistent as compared to the 2003–2004 follow-up PHENYCS study, despite an increase of more than 400,000 additional medical calls for help since 2011. As previously discussed, the clock starts when a victim stops breathing; in other words, the clock starts before 911 is called and leaves less than four minutes from the time of the call until CPR begins. While much improved, these response times—without bystander participation—do not provide the patient with an optimal chance of survival.

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[99] NYC Project Hypothermia Working Group, "Ongoing Changes in Resuscitation and Out-of-Hospital Cardiac Arrest Survival in a Major Metropolitan System," paper presented at the Resuscitation Science Symposium, 2014, abstract, http://circ.ahajournals.org/content/130/Suppl_2/A73.

[100] NYC Project Hypothermia Working Group, "Ongoing Changes."

[101] "FDNY Vital Statistics: Calendar Year 2014," FDNY.

[102] Ibid.

[103] The researcher compared the vital statistics as reported on the New York City website at Http://www.nyc.gov/html/fdny/html/general/vital_statistics.shtml.

An analysis of the available studies on NYC and the systems in place demonstrate that there has been an increase in OHCA survival. Indeed, New York City has reduced response times and implemented many successful programs and policies aimed at improving survival. Still, bystander CPR rates have been consistent throughout all of the studies, remaining in a range from 32 to 37 percent. NYC faces particular considerations that affect its response times, and thus its OHCA survival rate. A concerted effort to increase bystander participation may greatly impact survival rates from OHCA and bridge the gap between cardiac arrest and the arrival of first responders.

B.   THE HIGH-RISE CHALLENGE

With a greater number of high-rise structures than any other city in America, the iconic NYC skyline has long been unmistakably New York. But NYC is now experiencing a high-rise construction boom that is quickly altering the Manhattan skyline.[104] Moreover, high-rise structures are no longer confined to Manhattan; taller buildings are springing up in parts of the city where such construction has not previously been seen (see Figure 9).[105]

Figure 9.   Long Island City, Queens

Aerial picture taken in December 2015. The view looking east into Queens shows high-rise residential buildings along the East River. Most of these structures have been built in the past few years and demonstrate the recent construction trend in NYC. (Photo credit: Frank Leeb)

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[104] Nikolai Fedak, "Supertall City: New York's 2014 Boom," New York YIMBY, January 1, 2014, http://newyorkyimby.com/2014/01/supertall-city-new-yorks-2014-boom.html.

[105] Fedak, "Supertall City."

This new construction is not limited to high-rise office space, which had been the more common reason for the buildings in NYC. Many new residential buildings have been built or are soon slated for construction.[106] Records show that developers have submitted plans to the Department of Buildings for a 70-story building in Queens with an expected completion in 2019.[107] Another 16 structures have broken ground in NYC that will be at least 80 stories high.[108] These edifices are in addition to the recently constructed building at 423 Park Avenue, Manhattan, shown in Figure 10, which now stands as the tallest residential building in the Western Hemisphere at 96 stories.[109]

Figure 10.   423 Park Avenue, Manhattan

Aerial picture taken in December 2015. The view looking west into Manhattan—423 Park Ave, the tallest residential building in the Western Hemisphere, is the building right of center in this photo. (Photo credit: Frank Leeb)

This shift to more high-rise residential buildings at ever-greater heights has serious implications for someone suffering a cardiac arrest on an upper floor (see Figure 11 for photos of high-rise structures in downtown Brooklyn). The additional distance that first

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[106] Ibid.

[107] Jennifer Gould Kell, "Tallest Tower in NYC outside of Manhattan to Go up in Queens," *New York Post*, August 18, 2015, http://nypost.com/2015/08/18/tallest-tower-in-nyc-outside-of-manhattan-to-go-up-in-queens/.

[108] Kell, "Tallest Tower in NYC."

[109] "A New Icon," 432 Park Avenue, accessed December 18, 2015, http://432parkavenue.com/?state=432parkave.

responders must travel to reach a victim on an upper floor adds precious minutes to their response time—and, thus, delays their critical expert care.

Figure 11.   Downtown Brooklyn
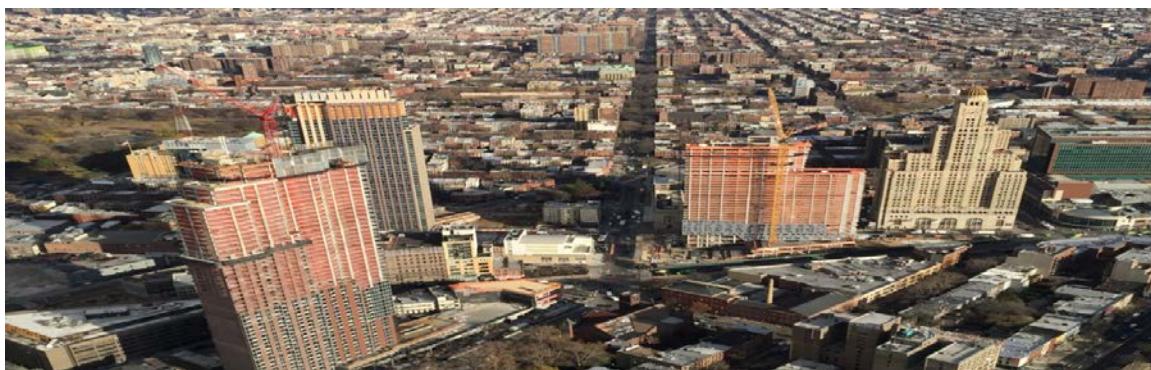
Aerial picture taken in December 2015. The view looking southeast into Brooklyn shows some of the high-rise structures under construction. (Photo credit: Frank Leeb)

A retrospective observational study of OHCA in Toronto confirms that survival from cardiac arrest is lower for patients residing on upper high-rise floors.[110] During the study period (2007–2012), there was a less than 1-percent survival rate for patients above the 16th floor and zero survivors above the 25th floor. The study revealed a 20-percent increase in the annual rate of cardiac arrests in private residences during the study period. Additionally, the use of an AED was very low (less than 1 percent), regardless of the floor on which the patient was located. This data is essential to understanding the impact of building height for patients of OHCA—specifically, the impact of building heights above the 16th floor. The 20-percent increase in cardiac arrests during the study can likely be attributed to the increase in high-rise building construction. The low rate of AED usage is nothing new; however, it indicates the importance of considering AED placement in high-rise residential structures, just as the low survival rates further underscore the importance of bystander CPR.

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[110] Ian R. Drennan et al., "Out-of-Hospital Cardiac Arrest in High-Rise Buildings: Delays to Patient Care and Effect on Survival," *CMAJ*, January 18, 2016, doi:10.1503/cmaj.150544.

III. POLICIES—THE STRATEGY FOR IMPROVEMENT

This chapter studies effective policy initiatives that have improved survival from OHCA by increasing bystander CPR rates. When combined with the other elements of the system, these policies provide the strategic framework for improving survival from OHCA. The researcher evaluated policies based on available data and identified those measures favorable to this study. This chapter examines the relationship of data collection, targeting training, bystander CPR rates, AED usage, and partnerships to increasing bystander CPR rates.

A. DATA COLLECTION—A CRITICAL FIRST STEP

A 2008 survey conducted in King County, Washington, was designed to define the reach of CPR training and to determine the public's confidence in applying the skills they learned.[111] In a telephone survey of randomly selected residents, respondents were asked a series of questions designed to assess their individual history of CPR training and their confidence in performing CPR. Additionally, respondents were asked questions to determine demographics, to the reach of CPR training, and segments of the population that may be underperforming by comparison.

The results of the survey revealed that 79.3 percent of respondents had received CPR training, with 40 percent reporting they were confident to perform CPR.[112] However, 52.9 percent of those who had been trained reported that they had received their training more than five years ago. Some 17.4 percent reported having received training within the past year. Additionally, 52 percent "reported that they were trained because it was required," and 23 percent "reported they were trained because the training was available at work or in their neighborhood."[113] Among the respondents who reported previous training, greater than 70 percent said they received CPR training more than one

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[111] K. Sipsma, B.A. Stubbs, and M. Plorde, "Training Rates and Willingness to Perform CPR in King County, Washington: A Community Survey," *Resuscitation* 82, no. 5 (2010), 564–7, doi 10.1016/j.resuscitation.2010.12.007.

[112] Sipsma, Stubbbs, and Plorde, "Training Rates."

[113] Ibid.

time. This is significant since the study revealed that the total times trained and the time since the person was last trained were important factors associated with a willingness to perform CPR.[114]

The respondents who reported a low confidence to perform CPR cited two common reasons: they had never been trained or they received training a long time ago.[115] The top reasons for not receiving training were that respondents had either not gotten around to it or did not think it was necessary, or that training was not available. Of note, the cost of training was not reported as a factor.

B.   TARGETED TRAINING

The results of the 2008 survey are significant to increasing bystander participation for a number of reasons. First, the survey identified a correlation between training— especially recent training—and the willingness and confidence of citizens to perform CPR.[116] The results also confirm that workplace training and CPR in school are effective for training large segments of the community. However, the survey also revealed that segments of the population may not have the same opportunities for training, and that targeting training may increase the number of people reached.

Possibly the most significant conclusion is the importance of data collection. Studies like this one can provide a baseline from which to improve an existing system of CPR training. For King County, the baseline data for comparison was a 1985 study; the 2008 study was used to evaluate the success of the system.[117]

In the 2008 King County survey, there were three segments of the community identified as less likely to have received CPR training: older respondents, men, and the less educated.[118] This data, according to the report, confirms earlier studies that identified similar associations. Studies, including this one, have recommended targeted training to

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[114] Ibid.

[115] Ibid.

[116] Ibid.

[117] Ibid.

[118] Ibid.

reach those more likely to be in position to help.[119] Together, data collection and targeted training can be used to tailor a community training program to increase bystander CPR. This customization enhances the efficiency of CPR training initiatives by directing training at those most likely to be in position to help, as well as segments of the community identified as having below-average training rates.

C.   CPR PROGRAMS IN SCHOOL

"About 5,920 children 18 years old and under suffer out-of-hospital cardiac arrest each year from all causes, including trauma, cardiovascular issues, and sudden infant death syndrome."[120] Inspired by the death of a Long Island 14-year-old who went into cardiac arrest on the lacrosse field, legislation was passed in New York in 2015 making CPR and AED training a high school graduation requirement.[121] New York was the 17th state to enact such legislation, and the momentum has continued to build; 26 states now have legislation requiring CPR training as a high school graduation requirement, with other states' bills awaiting passage (see Figure 12).[122]

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[119] Lynn P. Mandel, and Leonard A. Cobb, "CPR Training in the Community," *Annals of Emergency Medicine* 14, no. 7 (July 1985): 669–71, doi 10.1016/S0196-0644(85)80885-4.

[120] New York State Senate Bill S7096-2013, Amd §305, Ed L. "Requires the Commissioner of Education to Make Recommendations to the Board of Regents Relating to the Adoption of Instruction in Cardiopulmonary Resuscitation in Senior High Schools - New York State Senate."

[121] Nick Muscavage, "Regents Finalize CPR-in-Schools Rules," lohud, September 17, 2015, http://www.lohud.com/story/news/education/2015/09/17/regents-cpr-rules/32562889/.

[122] "Senate Passes CPR in Schools Bill," New York State Senate, June 12, 2014, http://www.nysenate.gov/press-release/senate-passes-cpr-schools-bill; Syeda. Ferguson, "Bill Would Require Students to Learn CPR," *Times Herald*, January 5, 2016, http://www.thetimesherald.com.

Figure 12.   States Requiring CPR Training in School

LIFESAVERS IN SCHOOL

Twenty-six states have passed laws or adopted curriculum changes to require hands-on, guidelines-based CPR training for high school graduation. Each year, more than 1.5 million public high school graduates will have been trained in CPR.

Sources: American Heart Association; National Center for Education Statistics, 2013-2014 school year

ANNUAL HS GRADUATES

AL	42,920
AR	28,540
CT	35,540
DE	8,120
GA	92,010
IA	32,310
ID	17,170
IN	65,940
LA	35,720
MD	56,990
MN	56,320
MS	25,720
NC	88,040
ND	6,980
NJ	92,220
NY	193,480
OK	37,300
OR	34,490
RI	9,460
TN	58,600
TX	291,830
UT	31,860
VA	79,900
VT	6,070
WA	65,310
WV	16,740
TOTAL	**1,509,580**

Source: "Be CPR Smart," American Heart Association, accessed January 31, 2016, http://www.be cprsmart.org/default.aspx.

The researcher was unable to locate studies that examined the long-term value of CPR training received in schools, specifically on the correlation that students trained in CPR will provide CPR if the situation presented itself during adulthood. However, there are many stories of CPR performed by adults who had learned the valuable CPR skill as a child. On the American Heart Association's "Be CPR Smart" website, a site that encourages stories related to CPR, many such stories exist.[123] What follows are two examples from BE CPR smart website highlight the importance of CPR training in schools, and the impact it can have on saving lives. In the first story:

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[123] "Be CPR Smart," American Heart Association, accessed January 31, 2016, http://www.be cprsmart.org/default.aspx.

A man suffered cardiac arrest in December of 2011. His heart defibrillator activated six times, but did not restart his heart as it was designed to do. He was unresponsive, his eyes were closed and his breathing had stopped. His wife Monica quickly began performing CPR on her husband, a skill she had learned thirty years ago in a Biloxi, MS middle school. Monica's husband lived due to her quick actions and her basic knowledge and training in CPR. A time may come when students will need to use the CPR training they can learn in schools. For Monica, it was thirty years later and she still remembered CPR enough to save her husband's life.[124]

In a second example,

It was June of 2011, two days after graduating high school in Wilmington, Delaware, Grace suffered from Sudden Cardiac Arrest. She had barely reached her mother's bedroom that night to tell her she wasn't feeling well before she collapsed on her mother's bed. Her mother called 911 as her brother rushed in and immediately started chest compressions, later followed by rescue breaths. EMTs were there within 3 minutes and took over. They shocked her with an AED a total of 6 times throughout the night. She spent 10 days at the hospital and later walked out with a newly fitted ICD (Implantable Cardioverter Defibrillator) in her left chest. Without her 24-year-old brother's knowledge of CPR, which was learned from his Red Cross certification in 6th grade, she would not be alive today.[125]

The American Heart Association further states,

Training students in CPR can be accomplished with a minimal investment in time and cost. According to the latest science, trainees including school children can achieve acceptable levels of CPR skills proficiency in 30 minutes or less. Pierson High School in Sag Harbor, NY began its CPR program in 1994. During that time, 16 lives have been saved so far because these students used their CPR skills in the real world. If the children from one school can save 16 lives, imagine how many lives could be saved if all students learned CPR before graduation.[126]

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[124] "Be CPR Smart," American Heart Association.

[125] Ibid.

[126] Ibid.

King County, Washington's EMS Division trains students in grades 6 through 12 how to perform CPR and use an AED.[127] Through a partnership, the students are trained by teachers and firefighters. The "goal is to provide CPR training to students three times prior to graduation from high school. In 2014, a total of 12,390 students were trained, while 41 teachers and other school staff were educated to become CPR instructors themselves."[128] The King County EMS Division also assists school districts with the proper placement of AEDs and in signing up for the King County AED Registry.[129]

Over time, CPR programs in schools will raise community bystander CPR rates and survival from OHCA. Part of the success in King County can be attributed to the success of their CPR in school initiative. However, for jurisdictions such as NYC where mandatory CPR training in school is a new law, changes in CPR training rates and OHCA survival may take time to garner measurable results.

D.   CPR AND AEDS—INCREASING BYSTANDER PARTICIPATION

In a *Journal of the American Medical Association* (JAMA) report, the results of a 10-year study in Denmark produced dramatic increases in survival rates for cardiac arrest survival.[130] From 2001 to 2010, recognizing a major health problem, Denmark had poor out-of-hospital survival rates for cardiac arrest. Over the review period, through several initiatives, Denmark increased the rates of bystander resuscitation and improved advanced care, improving the statistical chances of survival. During the study, bystander CPR increased from 21.1 percent in 2001 to 44.9 percent in 2010.[131] The percentage of patients who survived upon arrival at the hospital increased from 7.9 percent in 2001 to

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[127] Public Health Seattle & King County Emergency Medical Services Division, *2015 Annual Report to the King County Council* (Seattle, WA: Public Health Seattle & King County, September 2015), 19, http://www.kingcounty.gov/healthservices/health/ems/~/media/health/publichealth/documents/ems/2015-Annual-Report.ashx.

[128] Public Health Seattle & King County Emergency Medical Services Division, *2015 Annual Report to the King County Council*, 19..

[129] Ibid.

[130] Mads Wissenberg et al., "Association of National Initiatives to Improve Cardiac Arrest Management with Rates of Bystander Intervention and Patient Survival after Out-of-Hospital Cardiac Arrest," *Journal of the American Medical Association*, 310, no. 13, 1337–84, doi 10.1001/jama.2013.278483.

[131] Wissenberg et al., "Association of National Initiatives to Improve Cardiac Arrest Management."

21.8 percent in 2010. The percentage of patents achieving 30-day survival increased from 3.5 percent in 2001 to 10.8 percent in 2010 and the rate of one-year survival went from 2.9 percent in 2001 to 10.2 percent in 2010 (see Figure 13).

Figure 13.   Denmark Study 2001–2010
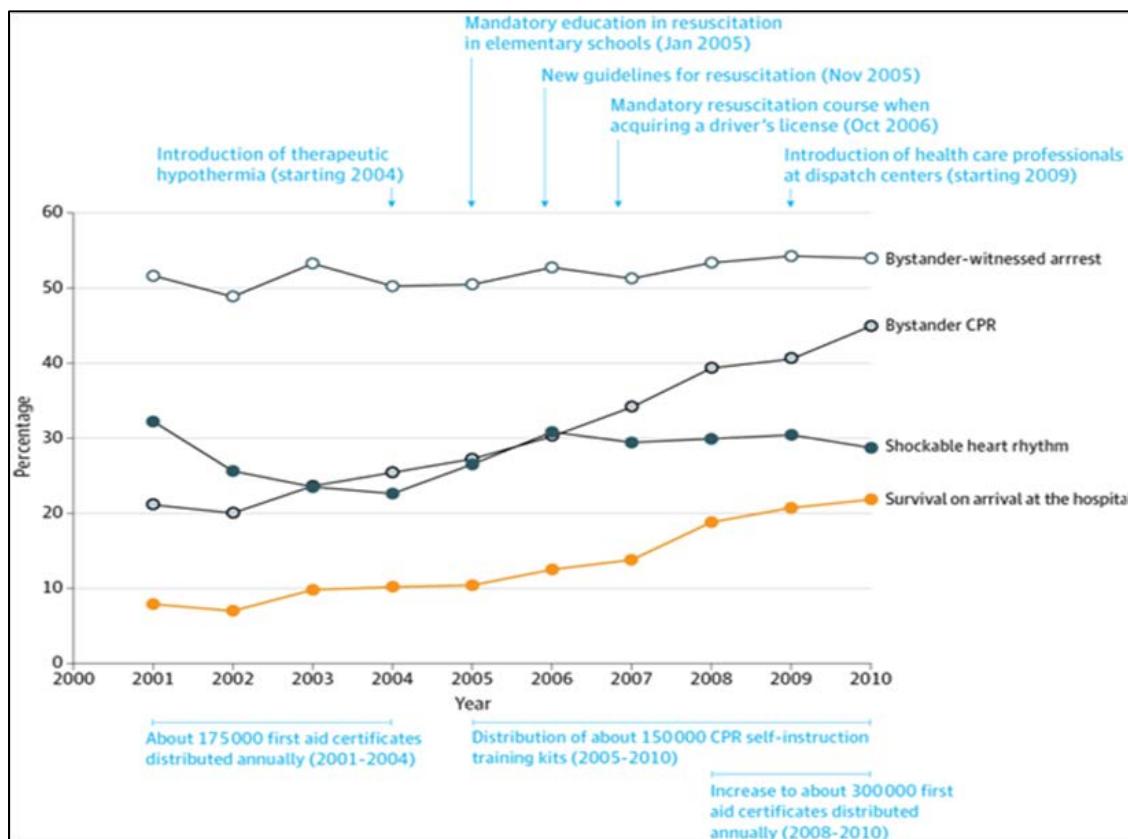
The one disappointing statistic of the study was the low usage of AEDs by bystanders. In 2010, at the end of the study, bystander use of AEDs remained very low, at 2.2 percent.[132] The low AED usage seen during this study may comport with assertions "that publicly available AEDs are rarely retrieved and used because bystanders generally

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[132] Ibid.

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cannot see them and have no way to know if an AED is available nearby."[133] In this case, the finding would further validate a technological solution or other mechanism to notify a potential user of the location of an AED.

During the study period, Denmark initiated several policies aimed at increasing bystander CPR, including:

- Mandatory CPR education in school in 2005

- Updated CPR guidelines in 2005

- Mandatory CPR training to receive a driver's license in 2006

- The introduction of healthcare-trained professionals at dispatch centers in 2009

- Increased focus on voluntary training throughout the period of study

These policy initiatives resulted in a large increase in the number of patients receiving bystander CPR. In two years (2008 and 2009), the study estimated that 15 percent of the Danish population participated in CPR training. The large increase of bystander CPR demonstrated in this study exemplifies the ability to change habits and shift the curve in favor of victims of cardiac arrest in a relatively short timeframe.

E.   AEDS IN THE COMMUNITY

While widely available today in public places, AED use remains low. As a critical component for increasing survival, locating and using these lifesaving devices continues to be a challenge. According to the Cardiac Arrest Registry to Enhance Survival (CARES), bystanders use AEDs before the arrival of first responders only 3.7 percent of the time.[134] Low rates of AED use were reaffirmed in a statewide study of cardiac arrests in North Carolina between 2010 and 2013; during the time period studied, bystanders

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[133] "Introducing PulsePoint AED," PulsePoint, accessed December 30, 2015, http://www.pulsepoint .org/pulsepoint-aed/.

[134] Amy L. Valderrama,"Out-of-Hospital Cardiac Arrest Surveillance—Cardiac Arrest Registry to Enhance Survival (CARES), United States, October 1, 2005—December 31, 2010," *CDC Surveillance Summaries* 60, no. SS08 (July 2011): 2, http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6008a1.htm.

initiated CPR 49 percent of the time while AED usage was low, at 13.4 percent.[135] The North Carolina study also revealed that few patients were defibrillated in the early period post-cardiac arrest, when defibrillation is most beneficial to the patient. However, when bystanders did use an AED, 33.6 percent of the patients survived to hospital discharge. Strategic efforts are needed to not only increase bystander defibrillation but to also improve the time until defibrillation. This would improve the odds of survival with favorable neurological outcome. Additionally, the study concluded that onsite AEDs are more likely to increase survival in densely populated areas, and that strategic AED deployment with AED linkage to emergency dispatch centers can facilitate AED identification.

In early 2004, the San Ramon Valley Fire Protection District Board requested the Fire District to study the feasibility of promoting AEDs in the community. The San Ramon Valley Fire District resides within Contra Costa County in the Northern part of California, about an hour drive East of San Francisco. Contra Costa County is approximately 716 square miles in size and, according to the 2010 census, has a population of 1,049,025. [136] The county comprises 19 smaller cities with fire and emergency medical services provided by six fire protection districts, with San Ramon Valley Fire Protection District being one of the six. The study request came in after a board member lost two coworkers to sudden cardiac arrest. This request and the resulting committee was the starting point for this system, which would improve over the following decade into a highly successful system focused on improving survival rates from sudden cardiac arrest "with a reputation as one of the safest places in the United States to experience a cardiac emergency".[137]

[135] Carolina Malta Hansen et al., "Association of Bystander and First-Responder Intervention with Survival after Out-of-Hospital Cardiac Arrest in North Carolina, 2010–2013," *Journal of the American Medical Association* 314, no. 3 (July 2015): 255–64, doi 10.1001/jama.2015.7938.

[136] *Wikipedia*, s.v. "Contra Costa County, California," accessed February 12, 2016, https://en.wikipedia.org/wiki/Contra_Costa_County,_California.

[137] San Ramon Valley Fire Department, "California Community's Cardiac Arrest Survival Rate Twice National Average," EMSWorld, June 30, 2015, http://www.emsworld.com/news/12088535/california-communitys-cardiac-arrest-survival-rate-twice-national-average.

Shortly after the request to study the feasibility of promoting AEDs in the community, the department established a committee with an initial focus on placing AEDs throughout the Fire District. The committee, the San Ramon Valley Public Access Defibrillation Community Partnership (PAD) began by reviewing and clarifying what the fire district's role would be within the PAD program.[138] In addition, the committee discussed funding, program oversight, and point of contacts with the county, and identified additional stakeholders to invite to their meetings.[139] They held general discussions on the wording of the message and goals of the program. The committee was presented with the 2003 cardiac patient data from the San Ramon Regional Medical Center emergency room. Included in this data were cardiac arrest statistics for the emergency room, noting 140 cardiac arrest patients.[140] This report also revealed that there were approximately 150 fatalities per year, including those that were deemed "dead in the field."

Although the PAD committee was moderately successful in placing AEDs into the community with donations from local rotary clubs and the San Ramon Regional Medical Center to purchase AEDs for the school district, they realized that the objectives of the committee needed to be expanded.[141] The PAD committee identified the lack of public awareness about the signs and symptoms of heart attack and the American Heart Association's "Chain-of Survival' as additional areas that should be addressed. [142]

F.   PARTNERSHIPS—ESTABLISHING COMMUNITY PROGRAMS

To expand and better reflect the PAD committee's objectives updated objectives, in 2009 the committee was renamed the HEARTSafe Community Initiative. With dual goals of establishing a HEARTSafe community program for the county and for San Ramon Valley to become a HEARTSafe community, the committee took the first step by

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[138] San Ramon Public Access Defibrillation Community Partnership Meeting Minutes, April 5, 2004.

[139] San Ramon Meeting Minutes.

[140] Ibid.

[141] Personal communication, Andy Swartzell, EMS coordinator San Ramon Valley Fire District, August 21, 2015

[142] Personal communication, Andy Swartzell.

designing the HEARTSafe application for their regional EMS agency, the Contra Costa County EMS. HEARTSafe programs are designed to promote survival from OHCA and to improve the Chain of Survival; in order to achieve HEARTSafe status, communities must meet minimum criteria.[143] With no external oversight, HEARTSafe programs are set up and managed independently by each state or regional jurisdiction.[144] Typical criteria include "increased availability to CPR instruction, public access defibrillators, and aggressive resuscitation protocols for first responders and area hospitals."[145] When the criteria are met, a certification is issued typically for two to three years, usually by the regional agency that serves as administrator to the program.[146]

The HEARTSafe application was developed in order to motivate the county's two largest cities to take action, and in 2011 the HEARTSafe program started. In that same year, San Ramon Valley was awarded the HEARTSafe designation. Since achieving their HEARTSafe status in 2011, they have taught over 6,500 prospective bystanders hands-only CPR and the use of an AED.[147] Later, the HeartSafe Community Committee became a sub-committee of the San Ramon Citizens Corps Council, with political support and a more consistent funding source. An ongoing program of the HeartSafe Committee as a result of this organization is the CPR in schools program.

Today, according to the San Roman Valley Fire Department,

The HeartSafe Community Committee is made up of representatives from the San Ramon Valley Fire Protection District, the City of San Ramon, the Town of Danville, the San Ramon Valley Unified School District, Contra Costa County Emergency Medical Services and many committed community members under the direction of the San Ramon Valley Citizen Core Council. The mission of the group is to encourage residents to learn hands-only CPR, promote the placement of public access AEDs in local

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[143] "HEARTSafe Communities," accessed December 5, 2015, http://heartsafe-community.org.

[144] "Frequently Asked Questions," HEARTSafe, accessed December 7, 2015, http://heartsafe-community.org/faq.

[145] "HEARTSafe Communities."

[146] "Frequently Asked Questions," HEARTSafe.

[147] San Ramon Valley Fire Department, "California Community's Cardiac Arrest Survival Rate."

businesses and community buildings, and facilitate the CPR in the Schools program.[148]

In the year prior to the two largest cities' involvement (2010), bystander participation was at 35 percent; by 2012, bystander participation increased to over 50 percent.[149]

"In 2014, a cardiac patient's chances of survival were higher in the San Ramon Valley than the national average, at 13.2 percent, but jumped to 71.4 percent for patients whose cardiac arrest was witnessed and who were in a shockable rhythm. A patient's chances of survival further jumped to 80 percent for a witnessed, shockable arrest and where a bystander performed some type of intervention like CPR or defibrillation."[150] The early recognition to alter the goals of the committee and to widen the scope and goals of the program—coupled with their ability to partnership with external groups—was central to the success of this system. The decision to form a community program that increased community partnerships had a great impact on bystander CPR rates and survival from OHCA.

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[148] "One of the Safest Places to Live," San Ramon Valley Fire Department, accessed February 6, 2016. http://www.firedepartment.org/news_events/displaynews.asp?NewsID=271&targetid=1.

[149] "One of the Safest Places to Live," San Ramon Valley Fire Department.

[150] Ibid.

IV. PEOPLE—TRAINING FIRST RESPONDERS, DISPATCHERS, AND BYSTANDERS

In a model response system, the dispatchers, bystanders, and first responders all play vital roles in saving victims of cardiac arrest. These are the three groups of people who interact within the system of OHCA response. This is where the rubber meets the road—where technology and established polices are intended to seamlessly interface with the anticipated participants. This chapter examines how each of these groups is trained, and why each is an important part of the response to victims of cardiac arrest.

A. DISPATCHERS—THE INITIAL CONTACT POINT

One of the often-overlooked components of increasing bystander CPR is the medical call takers or dispatchers. A dispatcher's ability to identify a victim in cardiac arrest quickly and properly provides the victim with his or her first and best chance at receiving bystander CPR, thereby increasing the chance of survival. Dispatchers should encourage CPR by providing "just in time" training CPR instructions to untrained bystanders thereby increasing the pool of those that can help.

As the initial contact point with the public, Emergency Medical Dispatchers (EMDs) have a significant opportunity to increase bystander CPR. They serve a dual function of dispatching medical resources and bridging the gap until the arrival of first responders by providing instructions for an untrained bystander who dials 911. In King County, Washington, dispatchers are trained by the EMS Division in Criteria-Based Dispatch.[151] The dispatchers triage calls using specific medical criteria and, based on signs and symptoms, dispatch the proper level of services to the incident basic life support (BLS) or advanced life support (ALS).[152] Importantly, after dispatchers send units to the incident, they continue to provide instructions to the caller for many types of emergencies until the first responders arrive. Cardiac arrest incidents are one of the

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[151] Public Health Seattle & King County Emergency Medical Services Division, *2015 Annual Report*, 18.

[152] Ibid.

medical emergencies that these dispatchers are trained to recognize and for which they give instructions.

All King County dispatchers go through a telecommunicator-CPR (T-CPR) course developed by the King County EMS Division.[153] This course "provides basic training to dispatchers in rapid recognition of cardiac arrest and timely delivery of telephone CPR instructions."[154] Over three hours, the web-based course also "reflects best practices consistent with international resuscitation guidelines" and "promotes recognition of cardiac arrest within one minute of receiving the 911 call, starting chest compressions within two minutes of the call, and identifying 90 percent of all cardiac arrests."[155] The T-CPR course uses dispatch recordings of actual 911 calls, and interactive quizzes and scenarios, and is divided into four modules:

- How to recognize cardiac arrest by asking the right questions

- How to effectively coach the caller to perform CPR

- Anticipating and managing potential missteps and challenges

- Special circumstances such as rescue breathing use of an AED and language barriers.[156]

The King County dispatch model and the training of Emergency Medical Dispatchers provide a model for building a successful dispatch system. By focusing on quality control, measured results, and hands-on training to keeps dispatchers ready for the low-frequency, high-consequence phone call reporting cardiac arrest, they have built a model system that has increased both community bystander CPR rates and cardiac arrest survival rates [157].

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[153] Ibid.

[154] Public Health Seattle & King County Emergency Medical Services Division, *2014 Annual Report to the King County Council* (Seattle, WA: Public Health Seattle & King County, September 2014), 18, http://www.kingcounty.gov/healthservices/health/~/media/health/publichealth/documents/ems/2014Annual Report.ashx.

[155] Public Health Seattle & King County Emergency Medical Services Division, *2014 Annual Report*, 18.

[156] Ibid.

[157] Ibid., 44, 74.

B. BYSTANDERS—THE "FIRST" FIRST RESPONDERS

In 2008, the American Heart Association issued a statement encouraging hands-only CPR (without rescue breathing) as an adequate alternative to conventional CPR for bystanders.[158] This has alleviated some bystander concern over providing mouth-to-mouth rescue ventilations while performing CPR.[159] Many municipalities, as well as the American Heart Association, regularly offer CPR classes to the public, often at no charge to the participant, eliminating any financial barrier that may be present. You can quickly learn hands-only CPR and prepare yourself to save a life by visiting the American Heart Association's website.[160]

The results of a five-year JAMA study highlight the importance of hands-only CPR in conjunction with a statewide public education campaign in Arizona. In this study, a bystander CPR rates after education increased from 28.2 percent to 39.9 percent.[161] Additionally, the likelihood of a bystander performing hands-only CPR versus conventional CPR went from 19.6 percent to 75.9 percent.[162] The results of this study are important, as they demonstrate that encouraging an easier technique (hands-only CPR) increases bystander CPR. Additionally, when combined with a public education campaign, barriers previously appearing insurmountable—such as reluctance to perform mouth-to-mouth and fear of not knowing how to perform conventional CPR—can be overcome.

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[158] "History of CPR," American Heart Association, accessed February 7, 2016, http://cpr.heart.org/AHAECC/CPRAndECC/AboutCPRFirstAid/HistoryofCPR/UCM_475751_History-of-CPR.jsp.

[159] Comilla Sasson et al., "Increasing Cardiopulmonary Resuscitation Provision in Communities with Low Bystander Cardiopulmonary Resuscitation Rates," *Circulation* 127 (February 2013): 1342–50, doi 10.1161/CIR.0b013e18288b4d.

[160] See "Two Steps to Staying Alive with Hands-Only CPR," American Heart Association, accessed February 13, 2016, http://cpr.heart.org/AHAECC/CPRAndECC/Programs/HandsOnlyCPR/UCM_473196_Hands-Only-CPR.jsp.

[161] Bentley Bobrow et al., "Chest Compression-Only CPR by Lay Rescuers and Survival From Out-of-Hospital Cardiac Arrest," *Journal of the American Medical Association* 304, no. 13 (October 2010): 1447–54, doi 10.1001/jama.2010.1392.

[162] Bobrow et al., "Chest Compression-Only CPR."

C.   FIRST RESPONDERS—A TIERED RESPONSE OF MEDICAL RESOURCES

Released in February of 2007 by the National Highway Traffic Safety Administration (NHTSA), the *National EMS Scope of Practice Model* was designed to help states develop scope-of-practice legislation, rules, and regulations.[163] This consensus-based document describes the four levels of EMS training that establish the national standards for skill and knowledge for EMS personnel.[164] Each state has the statutory authority and responsibility to regulate EMS and determine the levels of training they license. Many communities use a combination of the four training levels to meet their needs in a tiered response (see Figure 14).[165]

Figure 14.   Hierarchy of Pre-Hospital Medical Care
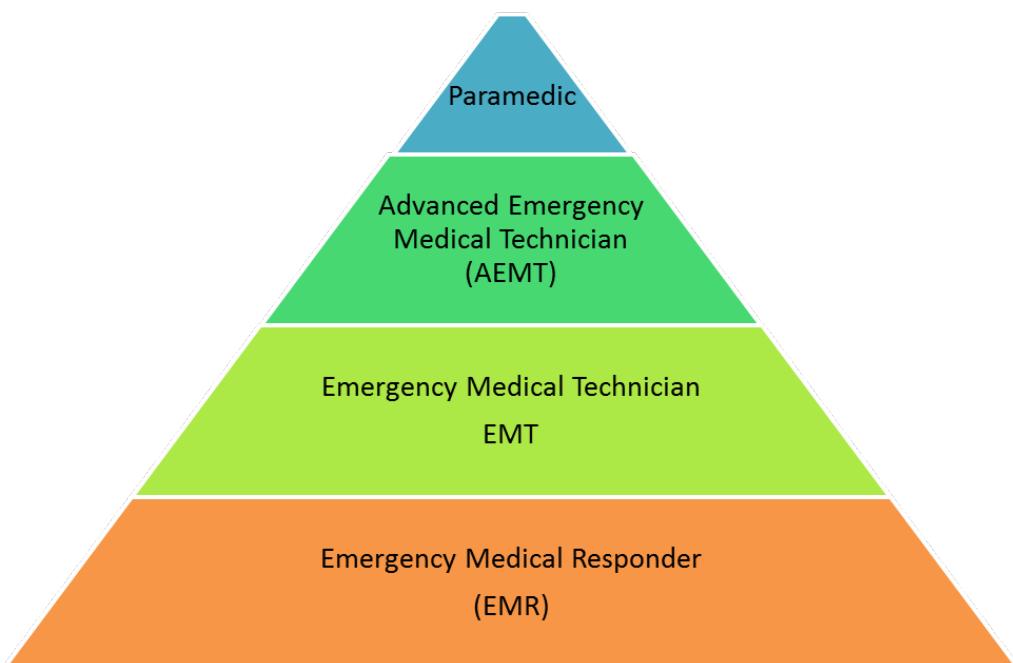
The bottom two levels of the pyramid are considered BLS and the top two levels of training are considered ALS. Adapted from National Highway Traffic Safety Administration, *National EMS Scope of Practice Model* (Washington, DC: National Highway Traffic Safety Administration, February 2007).

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[163] National Highway Traffic Safety Administration (NHTSA), *National EMS Scope of Practice Model* (Washington, DC: National Highway Traffic Safety Administration, February 2007), 4.

[164] NHTSA, *National EMS Scope of Practice Model*, 8.

[165] Ibid., 22–26.

The four levels of EMS training as outlined by NHTSA are as follows:

Emergency Medical Responder

The primary focus of the Emergency Medical Responder is to initiate immediate lifesaving care to critical patients who access the emergency medical system. This individual possesses the basic knowledge and skills necessary to provide lifesaving interventions while awaiting additional EMS response and to assist higher level personnel at the scene and during transport. Emergency Medical Responders function as part of a comprehensive EMS response, under medical oversight. Emergency Medical Responders perform basic interventions with minimal equipment.

Educational Requirements: One of the eligibility requirements for licensure at this level requires successful completion of an accredited Emergency Medical Responder training program.

Emergency Medical Technician

The primary focus of the Emergency Medical Technician is to provide basic emergency medical care and transportation for critical and emergent patients who access the emergency medical system. This individual possesses the basic knowledge and skills necessary to provide patient care and transportation. Emergency Medical Technicians function as part of a comprehensive EMS response, under medical oversight. Emergency Medical Technicians perform interventions with the basic equipment typically found on an ambulance. The Emergency Medical Technician is a link from the scene to the emergency health care system.

Educational Requirements: One of the eligibility requirements for licensure at this level requires successful completion of an accredited Emergency Medical Technician course.

Advanced Emergency Medical Technician

The primary focus of the Advanced Emergency Medical Technician is to provide basic and limited advanced emergency medical care and transportation for critical and emergent patients who access the emergency medical system. This individual possesses the basic knowledge and skills necessary to provide patient care and transportation.

Advanced Emergency Medical Technicians function as part of a comprehensive EMS response, under medical oversight. Advanced Emergency Medical Technicians perform interventions with the basic and advanced equipment typically found on an ambulance. The Advanced Emergency Medical Technician is a link from the scene to the emergency health care system. Educational Requirements: One of the eligibility

requirements for licensure at this level requires successful completion of an accredited Advanced Emergency Medical Technician course.

Paramedic

The Paramedic is an allied health professional whose primary focus is to provide advanced emergency medical care for critical and emergent patients who access the emergency medical system. This individual possesses the complex knowledge and skills necessary to provide patient care and transportation. Paramedics function as part of a comprehensive EMS response, under medical oversight. Paramedics perform interventions with the basic and advanced equipment typically found on an ambulance. The Paramedic is a link from the scene into the health care system.

Educational Requirements: Because of the amount of complex decision making, one of the eligibility requirements for licensure requires successful completion of a nationally accredited Paramedic program at the certificate or associates degree level.[166]

In New York City, a tiered response matrix is used. As part of this tiered response, firefighters trained as Certified First Responders (CFRs) are dispatched to life-threatening medical emergencies, such as cardiac arrest. The CFR firefighter training is equivalent to the EMR certification. Firefighters often arrive prior to the ambulance on cardiac arrest responses. For a cardiac arrest response, in addition to the CFR firefighters, one EMT and one ALS-staffed ambulance is dispatched. After the ambulance arrives, the firefighters continue to assist the more highly trained ambulance personal. Transportation is provided by the ALS ambulance with assistance from the EMT ambulance personnel.

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[166] Ibid., 20–21.

V.   TECHNOLOGY

A report released by the Pew Research Group in April of 2015 examines the increasingly important role that smartphones play in helping Americans access, share, and create information and communicate with others. The Pew researchers found that 64 percent of Americans now own a smartphone, up from 35 percent in 2011.[167] The report also found that smartphone usage is especially high among younger Americans age 18 to 29, with 85 percent in that age group using smartphones.[168] The data demonstrates that smart phone technology is increasingly a part of everyday life for millions of Americans. Further, it can be expected that future generations will follow the lead of millennials in technology usage and in their willingness to engage in ways never before possible.

However, despite advances in technology and the rising popularity of the smartphone, dead zones persist. These dead zones cause cell phone global positioning systems (GPS) to be unreliable in certain cases. In an example of how crowdsourcing can be used for public good, and how dead zones are a persisting issue, In January 2016 New York Senator Charles Schumer began a campaign to identify cell phone dead zones in NYC. The Senator. noting wireless service as an essential part of modern U.S. infrastructure, requested that anyone experiencing a dead zone report their findings on his web page.[169] Lack of wireless coverage, he explained, can be a safety concern, as it may render citizens unable to make an emergency call. In addition, he stated that tourists might avoid areas without reliable GPS technology.[170] Until the time that wireless service is considered critical infrastructure and carriers are required to provide consistent service, it is likely that these dead zones will persist. Today's technology may hold

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[167] Aaron Smith, "U.S. Smartphone Use in 2015," Pew Research Center, April 1, 2015, http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015.

[168] Smith, "U.S. Smartphone Use in 2015."

[169] Erica Siudzinski, "Crowdsourcing Campaign Aims to Eliminate Cellphone 'Dead Zones,'" QNS, January 19, 2016. http://qns.com/story/2016/01/19/sen-schumer-fights-cell-phone-dead-zones-with-crowdsourcing-campaign/.

[170] Siudzinski, "Crowdsourcing Campaign."

solutions that can transform the way people interact with society to facilitate a response to calls for help.

This chapter is divided into two sections. The first section describes technologies, specifically location-enabling technologies that may be adapted and used to facilitate bystander CPR. The second section focuses on the use of technology, specifically smartphone apps that can be used or adapted to locate victims and encourage bystander CPR.

A.   LOCATION-ENABLING TECHNOLOGY

The ability to accurately determine location is central to increasing bystander CPR, but a one-size-fits-all approach will not yield the best results. Several technologies can be combined to provide a series of viable options.

1.   Global Positioning System

GPS has transformed many aspects of daily life. From finding the best way home on a Smartphone app to picking the shortest lines on the ski slope, GPS is often the supporting technology. Operated by the United States Department of Defense and funded by the United States taxpayer, today global positioning systems are used by millions of people around the world.[171] Although owned and managed by the government, since the global positioning system was declared operational in 1995, it has never been turned off for military or other reasons.[172] In 2010, the United States ended its selective availability practice, which had limited the accuracy of publicly available global positioning systems.[173] The termination of this practice immediately improved publicly available GPS technology tenfold.[174] Today, a modernization of the global positioning system is underway that will further improve the accuracy of these systems in the future.[175]

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[171] "Frequently Asked Questions," GPS.gov, last modified July 31, 2014, http://www.gps.gov/support/faq/#howgpsworks.

[172] "Frequently Asked Questions," GPS.gov.

[173] "GPS Modernization," GPS.gov, last modified July 31, 2014, http://www.gps.gov/systems/gps/modernization.

[174] Ibid.

[175] Ibid.

On the other hand, today's GPS, like all radio-based services, is vulnerable to interference.[176] Atmospheric effects, sky blockage, and receiver quality can all affect GPS accuracy.[177] The global positioning system is a group of 31 satellites that are maintained in orbit.[178] It works by calculating position based on distance through the measurement of radio signals from multiple satellites in known positions in orbit.[179] Where there is an unobstructed line of sight to the satellites, location can be accurately determined. However, because these signals do not move easily through solid objects, the systems may not be accurate indoors.[180] This limitation has implications on the choice of the technology best suited to notify bystanders of the need for help in a specific location.

2. Geolocation/Assisted Global Positioning System

Wi-Fi-enabled devices transmit a unique hardware identifier called a MAC—a media access control address.[181] They are collected and used to develop geolocation databases, which are in turn used to speed up location identification for cell phones.[182] Geolocation apps are able to transmit your location to other users and associate your location with places of business or other landmarks.[183] With geolocation, when a global positioning-enabled smartphone has difficulty locating your position, it will use information from cell towers to triangulate your approximate position.[184]

Some geolocation systems use GPS and cell site triangulation, and in some instances local Wi-Fi networks, in combination to zero in on the location of a device; this

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[176] "Frequently Asked Questions," GPS.gov.

[177] "GPS Accuracy," GPS.gov, last modified September 18, 2014, http://www.gps.gov/systems/gps/performance/accuracy/.

[178] "GPS Accuracy," GPS.gov.

[179] Hans Frederick, "Why Doesn't GPS Work Inside a Building?" Opposing Views, accessed December 27, 2015, http://science.opposingviews.com/doesnt-gps-work-inside-building-18659.html.

[180] Frederick, "Why Doesn't GPS Work Inside a Building?"

[181] Declan McCullagh, "Removing Your Wi-Fi Network from Google's Map," CNET, November 14, 2011, http://www.cnet.com/how-to/removing-your-wi-fi-network-from-googles-map.

[182] McCullagh, "Removing Your Wi-Fi."

[183] Daniel Ionescu, "Geolocation 101: How it Works, the Apps, and Your Privacy," TechHive. May 10, 2010, http://www.techhive.com/article/192803/geolo.html.

[184] Ionescu, "Geolocation 101."

is known as assisted GPS. Like global positioning systems, this technology may not be reliable in specific environments. Using this technology as a backup system in conjunction with a global positioning system, however, may give it value for better coverage indoors.

3. Radio-Frequency Identification

Radio-frequency identification (RFID) technology uses radio waves to identify people or objects by using a device that reads information from a distance.[185] This information is contained on a wireless device or tag. Highway toll tags, employee identification, and security access cards are all uses of RFID technology.[186] Unlike GPS, RFID is not dependent on connecting with satellites, and can function with local transmitters and receivers within a building.

Because RFID is not dependent on connecting with satellites, it may provide a more reliable solution in certain environments. In an experiment conducted by the University of Washington, a web-based RFID "ecosystem" was developed.[187] During the experiment, they tracked every item with RFID tags. This type of system can be modified to track occupants within a high-rise structure. Because radio signals can be limited in certain environments, particularly below-grade areas and areas with solid objects such as the upper floors in high-rise buildings, this type of system may be able to overcome some of the limitations of location technology found in cell phones and other global positioning devices. Another option for buildings that are very tall is to establish smaller RFID "micro communities." It is common for some building tenants to occupy several floors within a building. These tenants can set up a micro RFID community—an RFID system to serve the specific floors which they occupy. These RFID communities, used to track the occupants in the building, may reduce security and building access concerns by

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[185] "Radio Frequency Identification (RFID): What Is It?" Department of Homeland Security, accessed December 27, 2015, http://www.dhs.gov/radio-frequency-identification-rfid-what-it.

[186] "Radio Frequency Identification," Department of Homeland Security.

[187] E. Welbourne et al., "Building the Internet of Things Using RFID: The RFID Ecosystem Experience," *IEEE* 13, no 3 (May–June 2009): 49, doi 10.1109/MIC.2009.52.

allowing access based on RFID chips imbedded into worker identification cards or badges.

The inhabitants of these micro communities can benefit from RFID technologies by use of a database that can quickly identify employees trained in CPR, or employees who serve on the building's fire brigade. When a person is in need of help, building security or another individual can determine who in the building is trained, and notify them that help is needed. Additionally, a building's fire safety director or floor fire wardens can be trained in CPR to ensure a quick response from trained personnel at all times.

4.   Near Field Communication

Near field communication (NFC), an offshoot of RFID, is designed for use by devices within close proximity to each other and uses electromagnetic radio fields to transfer data.[188] Devices using NFC may be active or passive. A passive device contains information that other devices can read but does not read any information itself, while active devices can read and send information.[189] NFC is widely used in many industries and in innovative ways—Apple Pay and Google Wallet are two examples of NFC that have gained recent popularity. Many smartphones have NFC technology as well, including newer Apple smartphones, from iPhone 6 forward.[190] Since NFC is designed for use by devices in close proximity to each other, it is best suited for this application when used in conjunction with an identification card or other security device. One potential use for this technology can be to track CPR-trained employees in a high-rise office building. When they scan a security ID card to enter their place of employment, their name, work location, and CPR qualification can be entered into a data bank that can be used for notification when someone is in need of CPR.

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[188] "How NFC Works," Near Field Communication.org, accessed December 27, 2015, http://www.nearfieldcommunication.org/how-it-works.html.

[189] "How NFC Works," Near Field Communication.org.

[190] Daniel Howley, "What Is NFC, and Why Does it Matter for the iPhone 6?" Yahoo, September 3, 2014, https://www.yahoo.com/tech/what-is-nfc-and-why-does-it-matter-for-the-iphone-6-96456683964.html.

B.   SMARTPHONE APPLICATIONS AND LOCATION TECHNOLOGY

With more than 1.4 million apps available for Apple products, there is an app for almost everything.[191] Apps that use location technology are among the most popular apps and are able to help users avoid traffic, share a location with a friend, or notify a stranger that CPR is needed. We can expect adaptations to these apps as well as new apps and advanced technology to come into the market that continue to contribute to society in ways we have not yet considered. This section provides a brief sampling of innovative apps now using location technology. One of these apps is already helping victims of cardiac arrest by notifying people when nearby CPR is needed. Others are offered here to illustrate how location enabling technologies are opening up new avenues for citizens to connect using technology, crowdsourcing, and a smartphone.

1.   Pulse Point

Originally developed and tested for over a year by the San Ramon Valley Fire Protection District in California, the smartphone app Pulse Point is now used by more than 1,200 cities and 24 states across the nation.[192] Used to increase awareness of the approximately 1,000 people who suffer sudden cardiac arrest daily in the United States, Pulse Point notifies CPR-trained citizens of cardiac arrest cases in need of immediate assistance; the app also has a Twitter account to tweet out requests for CPR to its member communities.[193] The researcher has been following their activity since October 2014 and was surprised at the number of activations that are tweeted out every month.[194]

Designed to support public safety agencies, the Pulse Point Respond application is location enabled and combines GPS with a smartphone application. It alerts users by push notification when they are near a cardiac arrest and they have indicated they are trained in

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[191] "App Store Rings in 2015 with New Records," Apple, January 8, 2015, https://www.apple.com/pr/library/2015/01/08App-Store-Rings-in-2015-with-New-Records.html.

[192] Heather Caspi "App Makes Bystanders Key in Cardiac Arrest Survival," Firehouse, December 10, 2012, http://www.firehouse.com/article/10839819/pulsepoint-mobile-app-helps-sudden-cardiac-arrest-survivors-with-cpr-aeds; Pulse Point, accessed December 26, 2015, http://www.pulsepoint.org/news/.

[193] "PulsePoint Respond," PulsePoint, accessed December 30, 2015, http://www.pulsepoint.org/pulsepoint-respond.

[194] Follow pulse point on Twitter @1000livesaday.

CPR and willing to assist in a public place.[195] The app works by connecting the dispatch data to the Pulse Point service and simultaneously dispatching advanced medical care personnel and CPR-trained citizens.[196] CPR-trained citizens are provided with the location of the closest publically accessible AED (see Figure 15).[197] Such technology gives citizens the ability to intervene for the first time.

Figure 15.   Pulse Point App
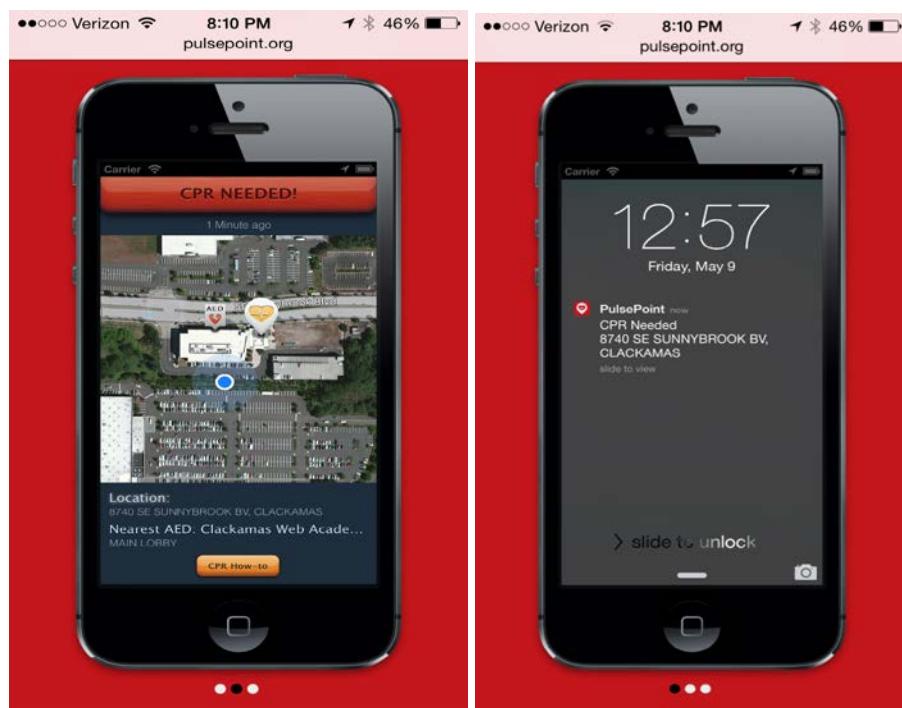
Display screen indicating that CPR is needed.

The companion app for Pulse Point is the Pulse Point AED app. This app enables users to log public AEDs into the app. The pulse point AED website states that "publicly available AEDs are rarely retrieved and used because bystanders generally cannot see them and have no way to know if an AED is available nearby."[198] This application should lead to greater use and knowledge of AED locations. "Statistics from the Cardiac

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[195] "PulsePoint Respond," PulsePoint.

[196] Ibid.

[197] Ibid

[198] "PulsePoint AED," PulsePoint.

Arrest Registry to Enhance Survival (CARES) registry indicate that publicly available AEDs are used less than 3 percent of the time when needed and available."[199]

2. Glympse

Glympse is a popular app with more than 10 million users that made *Time* Magazine's list of the best 50 applications for 2013. Transmitting your location and ETA to people you choose, this application has many uses (see Figure 16).[200]

Figure 16. Glympse App
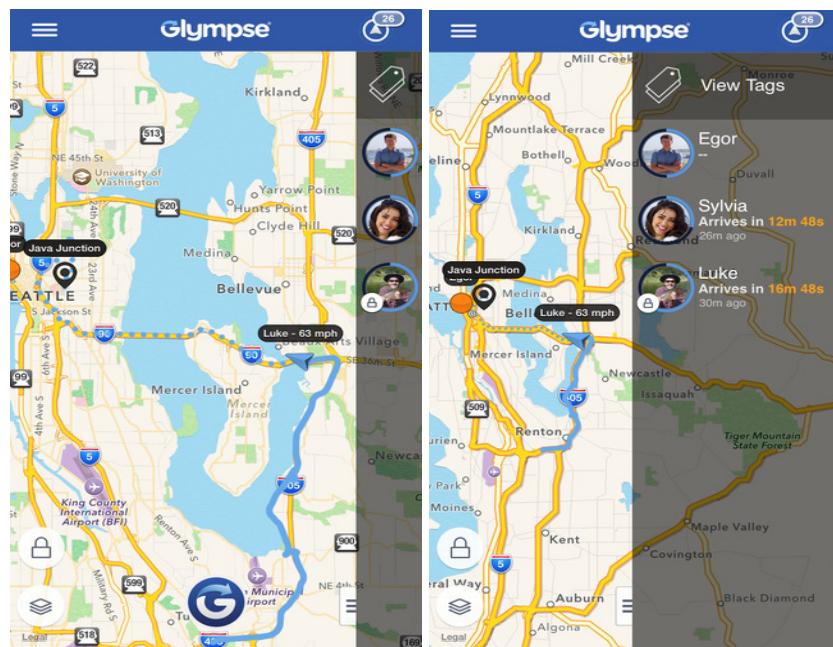
While this application does not have any current relevance to EMS response, it is a location-based technology that demonstrates the versatility and variety of this technology's use. This application, modified to include notifications of cardiac arrest, would be beneficial to communities that use this app.

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[199] Ibid.

[200] "What Is Glympse," Glympse, accessed March 2, 2015, https://www.glympse.com/what-is-glympse.

3. Waze

Waze is the world's largest community-based traffic and navigation app.[201] It has accomplished this feat by passively using location-based technology to crowdsource the exact location of those using the app (see Figure 17).[202] The app then provides driving routes, using the real-time data to guide users away from traffic congestion. Users also have the option to report hazards, car accidents, and other information that is used to update driving routes.[203]

Figure 17.   Waze App
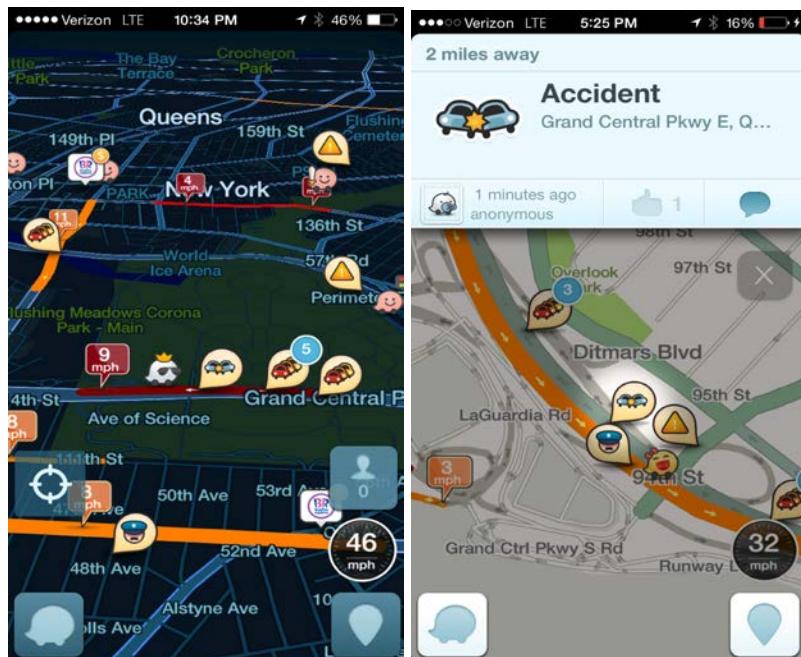
Screen shots showing reported accidents in real time.

The researcher has used Waze at work on many occasions when assigned to respond to car accidents on local highways. From the researcher's experience, 911 calls reporting the location of car accidents on highways are frequently unreliable, with the reported location sometimes a considerable distance from the actual accident location.

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[201] "Waze," iTunes, accessed December 29, 2015, https://itunes.apple.com/us/app/waze-gps-maps-social-traffic/id323229106?mt=8.

[202] "Waze," accessed December 29, 2015, https://www.waze.com/about.

[203] "Waze."

This results in unnecessarily longer time for help to arrive. The Waze app, to a large degree, has eliminated the confusion of accurate reporting of car accidents, thanks to its location-based technology. When a user reports a car accident on Waze, the location-based technology accurately marks the correct location and direction to guide users away from the area. This unintended use of Waze provides one example of how location-based technology can be adapted for use to save lives by enabling first responders to arrive quickly to render help to car accident victims.

4.   Nextdoor

Nextdoor is a geolocation app that creates a private network with a verification process for users. The app enables users to connect with nearby neighbors to create a virtual neighborhood designed with the feel of a virtual community watch group, or civic association (see Figure 18).

Figure 18.   Nextdoor App
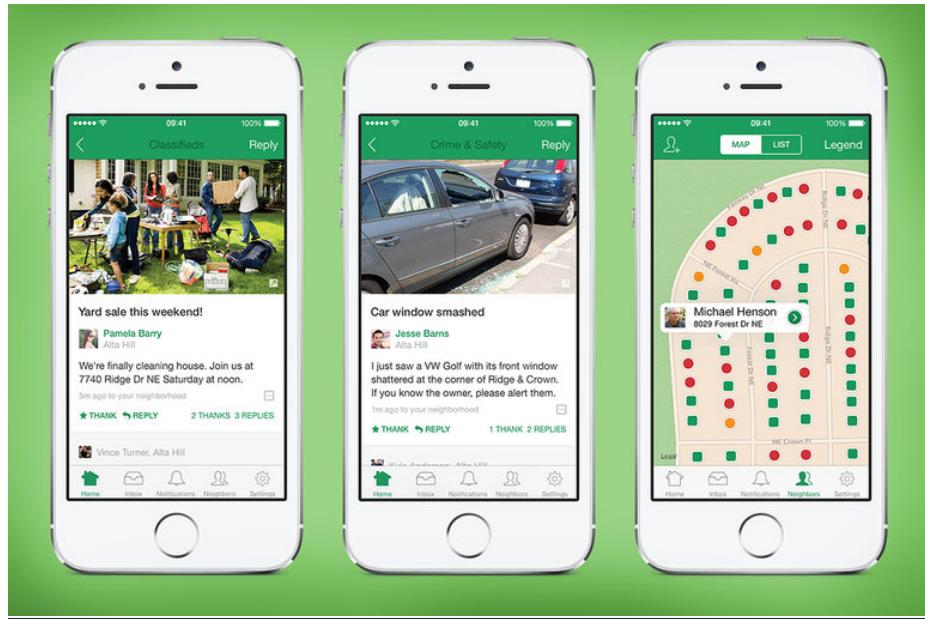
Features of the app allow a subscriber to post about yard sales, report on crime, notify neighbors of a lost dog, and other activities that a small community might discuss.[204] A new element of the Nextdoor app is the ability for police and fire departments to send out information on the app to target specific locations.[205] The Boise Police Department became the 137th police department in country to sign on with Nextdoor, using the app as a social media tool to share information and educate residents to improve public safety.[206] According to the Nextdoor website, over 86,000 communities have already been established.[207]

The Nextdoor app provides another example of how location-based apps combine technology and crowdsourcing for public good. Referring to community member involvement in reporting crime and other activities, Sacramento, California Police Chief Sam Somers states, "If we want to have the safest big city, I need their help."[208] Chief Somers further stated that crime is down 24 percent in the roughly two years that Sacramento has used the Nextdoor app.[209] Adding a CPR-needed element into this system would quickly reduce response times for CPR-trained responders within these communities.

Technology to transform response may already be available. Many of the apps and technologies presented in this chapter hold great potential. The challenge will be identifying future technologies while adapting current technology to maximize their beneficial use.

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[204] "Nextdoor," accessed December 29, 2015, https://nextdoor.com.

[205] Carmel DeAmicis, "Neighborhood Social Networking App Nextdoor's New Safety Feature Makes it a Must-use," Gigaom, September 30, 2014, https://gigaom.com/2014/09/30/neighborhood-social-networking-app-nextdoors-new-safety-feature-makes-it-a-must-use/.

[206] "Boise Police Join Nextdoor.com," City of Boise, January 27, 2014, http://police.cityofboise.org/home/news-releases/2014/01/boise-police-join-nextdoorcom/.

[207] "Nextdoor."

[208] Andria Chamberlain. "Crowdsourcing App Can Help Police Catch Criminals." *Wall Street Journal*, May 13, 2014, http://www.wsj.com.

[209] Chamberlain, "Crowdsourcing App."

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VI.   FINDINGS, RECOMMENDATIONS, AND CONCLUSIONS

It is 7 o'clock on a Monday morning on the 45th floor of a downtown high-rise office building. A young executive has just finished his cardio workout and is ready to begin his workday. Suddenly, he falls to the ground just outside of his office. His secretary, who is nearby, quickly runs to his side and recognizes that he is not breathing and in need of CPR. Having recently participated in the company's emergency response training program, she knows what to do and immediately calls for help and begins hands-only CPR.

Soon after her call for help, an announcement is made over the building public address system that CPR is needed on the 45th floor. Moments later, another co-worker arrives and is sent to get the automated external defibrillator located in the elevator lobby.

Two minutes later, a civilian trained in CPR arrives at the scene to help; he had been in the bank across the street when he received notification on his cell phone that there was a person in cardiac arrest and in need of CPR close to his location. Together, the three bystanders are performing CPR, have applied the AED, and have delivered a life-saving shock to the patient.

At the same time, down the block at the fire station, the fire alarm bell sounds reporting a male in cardiac arrest in the high-rise office building. The firefighters quickly board the fire engine and leave the fire station, moving rapidly through the heavy traffic and arriving at the scene in four minutes.

The firefighters, all trained as EMTs and paramedics, board the elevator and head to the 45th floor. Upon the firefighters' arrival, they take over the responsibility of CPR while starting advanced medical procedures.

Within two minutes, thanks to the quick response of the bystanders and firefighters, the patient regains a pulse and begins breathing but is still in critical condition. One minute later, the ambulance crew arrives at the scene and the patient is quickly moved for transport to the hospital. The patient arrives at the hospital and is transferred to the waiting team of doctors and nurses who provide him with state-of-the-art advanced medical care. The patient continues to improve and is eventually released from the hospital. Soon, he is back at work thanks to the quick, coordinated, and multi-tier response of bystanders, firefighters/paramedics, the ambulance EMS crew, and the staff of doctors and nurses at the local hospital.

This example depicts the future, when bystanders and fire and EMS units—along with innovative technology—collaborate to increase survival from out-of-hospital cardiac arrest in New York City. This thesis' proposed recommendations build on particular observations about the current emergency response system in New York City, specifically on the relationship between first responders, civic engagement, and the environment in which they interact to help those in cardiac arrest.

A. FINDINGS AND FUTURE RESEARCH

The focus of this thesis was specifically to provide recommendations that increase bystander participation to save victims of OHCA. While studying available data, the researcher discovered the following findings that could provide useful as further areas of study or possible areas of improvement:

- Many jurisdictions do not currently use EMD-trained dispatchers.

- While there are recommended standards to evaluate cardiac arrest data, there are no mandated requirements for tracking and publicly releasing data. Further, many jurisdictions may not track cardiac arrest data or their data is incomplete.

- Methods used to report cardiac arrest data can vary greatly between jurisdictions due to how the numbers are reported and how data is collected. Additionally, data is often incomplete or missing.

- The increased construction of high-rise buildings in NYC will pose future challenges to NYC and the FDNY.

- If the current trend of increasing medical responses continues in NYC, additional resource allocation and alternative methods of pre-hospital care will be required.

- Elevators are often too small to effectively perform quality patient care while removing a patient from an upper floor in a building. Future building codes and legislation must consider the barriers that current buildings present to first responders.

B.   RECOMMENDATIONS

This section presents decision-makers with recommendations aimed at reducing needless deaths associated with OHCA by increasing bystander CPR participation. This section contains three main groups of recommendations—each group begins with a general overview of the section and is followed by subtopics that define the recommendations.

1.   Policies—The Framework for Building Success

Policies provide the strategic framework for improvement and the necessary mechanism for evaluation. It is in the development and institution of policy where long-term strategies are put in place.

a.   *Baseline Data Collection Survey*

Data collection is needed in the form of a random question survey to tailor community training programs to best increase bystander CPR. The random question survey should seek to identify the percentage of the overall community's population that has been trained in CPR. This data can then be used to determine the success or failure of current training while identifying groups beneficial to target for increased training. Part of this survey should include questions about demographics and questions related to CPR training history, including the last time the person attended CPR training, his or her willingness to perform CPR, and his or her confidence in performing CPR.

b.   *Emergency Medical Dispatchers as Just-in-Time Trainers*

One of the often-overlooked components of increasing bystander CPR is the medical call takers or dispatchers. The dispatcher's ability to quickly and properly identify a victim in cardiac arrest provides the victim with his or her first and best chance of receiving bystander CPR. While dispatcher instructions can greatly increase survival in many scenarios, perhaps the greatest benefit will be seen in residential occupancies where most cardiac arrests occur.[210] This section provides recommendations to improve dispatcher training.

Dispatchers should encourage CPR by providing (just-in-time training) CPR instructions to untrained bystanders. To accomplish this goal, dispatchers should receive the best possible training with a focus on quickly recognizing a cardiac arrest event, encouraging bystander CPR, and giving proper directions to the bystander. This training should incorporate scenario-based training, individual feedback on each cardiac arrest event, and a review of the audio recording of each 911 call for a cardiac arrest. Additionally, there need to be high quality-control mechanisms that track data on accuracy of recognition of cardiac arrest events and other data that can be used as a baseline for improving the system. This data should also be used to identify and recognize high- and low-performing dispatchers. It is further recommended to model the telephone-assisted CPR (T-CPR) dispatcher training program in place in King County, Washington, which has a success rate of greater than 90 percent in quickly identifying cardiac arrests (see Figure 19).

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[210] Fredrik Folke et al., "Differences between Out-of-Hospital Cardiac Arrest in Residential and Public Locations and Implications for Public-Access Defibrillation," *Circulation* 122 (2010): 623–30, doi 10.1161/CIRCULATIONAHA.109.924423.

Figure 19.   The Four Critical Steps of a Successful EMD Program

Bystander
calls 911

Dispatcher
accurately
identifies cardiac
arrest and
provides CPR
instructions to
bystander

Bystander
performs CPR
until the arrival
the of first
responders

Bystander
recognizes need
for medical help
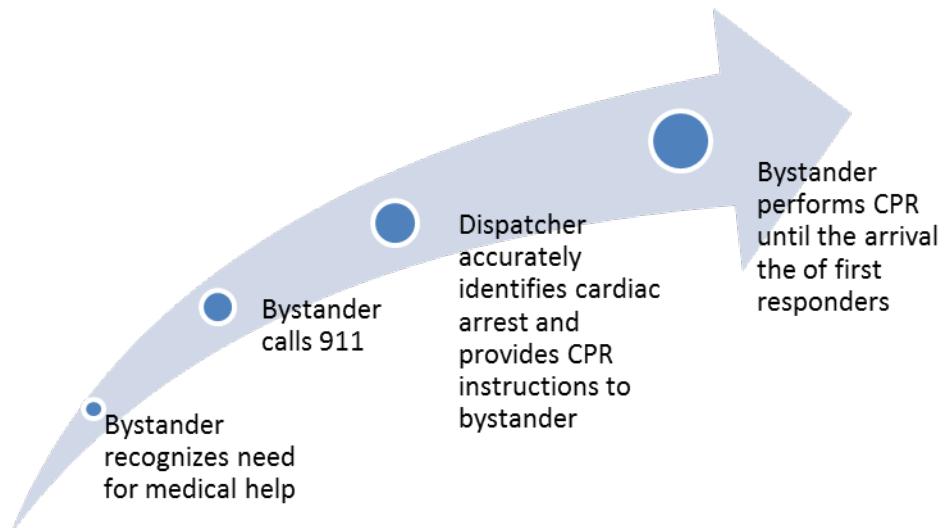
Adapted from: Public Health Seattle & King County Emergency Medical Services Division, *2014 Annual Report to the King County Council* (Seattle, WA: Public Health Seattle & King County, September 2014), 18, http://www.kingcounty.gov/health services/health/~/media/health/publichealth/documents/ems/2014AnnualReport.ashx.

c.   *Increase CPR Training through Partnerships and Target Training*

According to the FDNY, the "Be 911" Compressions-Only CPR program has trained 50,000 people.[211] Even with a training program in place, in a population of over eight million people, it is likely that this training does not effectively increase the percentage of CPR-trained bystanders. Moreover, an evaluation of the PHASE and PHENYCS studies—as well as of preliminary 2015 data obtained by the author— demonstrates that bystander CPR has remained fairly constant in a range of 30 percent to 38 percent.[212]

This line of recommendation for improving survival rates is to increase the percentage of trained bystanders in NYC. Since the percentage of CPR-trained citizens in NYC may be low, this may initially require targeting training to train those most likely to be in a position to help. Until a study is conducted to determine the current percentage of

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[211] "Public CPR Training," FDNY, Accessed December 23, 2015, http://www.nyc.gov/html/fdny/ html/cpr/index.shtml.

[212] Contact author for 2015 data report.

trained public, the concept of these recommendations is to concentrate on who we train as compared to how many we train (see Figure 20 for a target training diagram).

Figure 20.   Example of Target Training
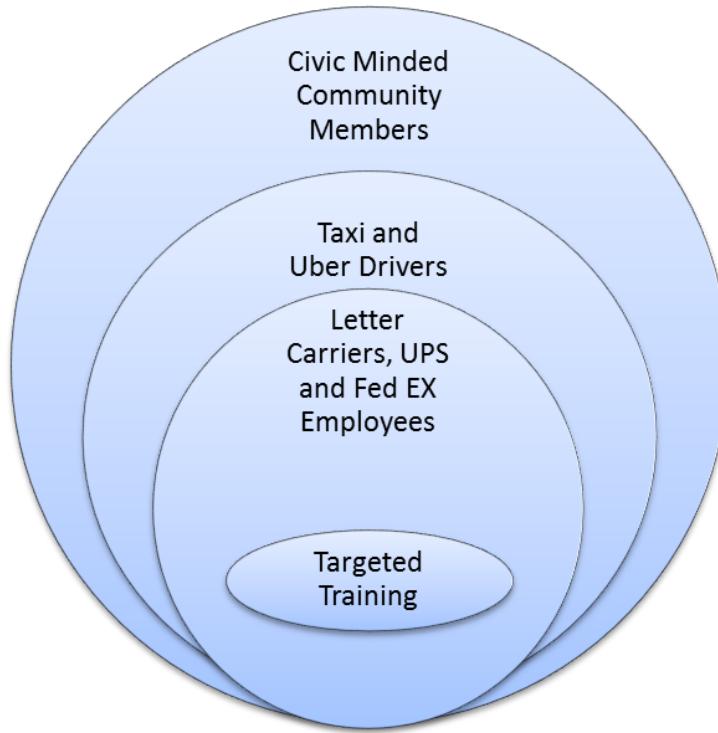
The web of coverage for civic-minded bystanders willing to perform CPR should be structured similar to a network of Uber drivers, in which you can request a ride and have a car to your location within minutes. This network is possible if the right bystanders are targeted and trained in CPR. Based on the results of the random question survey (or on the premise that people are more likely to help those in their in-group), targeting specific groups may increase bystander CPR rates. These groups include the people that, throughout the day, are visible around our communities and have an increased likelihood of being nearby when a person suffers cardiac arrest. Letter carriers, delivery company employees (UPS, Fed Ex, etc.), taxi drivers, sanitation workers, utility workers, and cable and telephone installers are all examples of groups that can be targeted to receive CPR training. Training these groups to supplement existing first

responders will provide an army of people already deployed around the community, able to respond to calls for assistance at a moment's notice. Couple these targeted training groups with off-duty members of the community who serve as firefighters, police officers, doctors, nurses, EMTs, paramedics and other civic-minded community members, and you have a formidable contingent of trained responders spread throughout the community.

Training the public in CPR can be greatly enhanced through partnerships. Corporate and other partnerships that encourage CPR training for their employees can greatly impact the number of people trained. Likewise, partnerships with schools can make possible a generation of young people trained in CPR. These initiatives can be monitored and tracked through partnerships with community organizations such as the American Heart Association and through the department's CPR training unit.

The FDNY should also seek out additional partnerships in the public and private sectors to increase CPR training. Since 2004, the FDNY has conducted targeting with a partnership with the Department of Education by sponsoring the FDNY High School.[213] As part of the curriculum, students receive EMT training. This program, which targets high-school-age kids with a desire to pursue a career as first responders, provides a valuable ancillary value to the neighborhoods where these kids live, work, or play. Additionally, initiatives such as the FDNY High School help increase awareness and training to increase participation.

How will bystanders know when their assistance is needed? Short of witnessing the cardiac arrest, an effective notification system needs to be put into place. Technology may hold solutions that enable willing civilians, trained in CPR, to receive notification that a person is in cardiac arrest and in need of help.

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[213] "FDNY High School for Fire and Life Safety," NYC Department of Education, accessed January 11, 2016, http://schools.nyc.gov/ChoicesEnrollment/High/Directory/school/?sid=4833.

2. People—Public Awareness and CPR

Many of the recommendations in this thesis are only as good as the education and awareness about increased bystander CPR, the importance of quick, hands-only CPR, and the knowledge of the difference that a bystander can make.

a. Public CPR Training

While there are other educational barriers still to overcome—such as the numerous languages spoken in New York City and the misguided fear of liability—education about the American Heart Association's hands-only CPR is perhaps the largest hurdle. Training classes should be widely available. Additionally, alternative methods should be evaluated and implemented to further expand the reach of training. CPR training videos can be posted on popular social media sites such as Youtube and Periscope to reach people who would otherwise not attend training. Further collaboration to increase partnerships should also be initiated. This could lead to corporations hosting CPR training for their employees.

b. Media Campaigns

Studies have demonstrated that media campaigns increase peoples' willingness to use an AED and also raise their confidence to perform chest compressions.[214] Identified barriers could be overcome with proper education campaigns. Hands-only CPR and the importance of bystander CPR can be promoted with television and radio advertising. Alternatively, social media could be leveraged as a cost-effective method to quickly reach many people. As of December 2015, the combined FDNY and NYPD Facebook and Twitter accounts had over 1.2 million followers (see Figure 21). [215] Leveraging the social media following of these four accounts alone will reach a large audience.

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[214] Nielsen et al., "Can Mass Education and a Television Campaign Change Attitudes."

[215] See www.facebook.com/FDNY, www.facebook.com/NYPD/, https://twitter.com/fdny, https://twitter.com/NYPDnews.

Figure 21.   FDNY and NYPD Twitter and Facebook Account Followers

Twitter
• @NYPDnews
• 186,000 followers

Facebook
• www.Facebook.com/NYPD/
• 507,000 followers

Twitter
• @FDNY
• 148,000 followers

Facebook
• www.Facebook.com/FDNY/
• 370,000 followers

Leveraging the power of social media—as of December 2015, the FDNY and NYPD Twitter and Facebook accounts had over 1.2 million followers. See www.facebook.com/FDNY, www.facebook.com/NYPD/, https://twitter.com/fdny, https://twitter.com/NYPDnews.

With the popularity of Facebook, Twitter, Instagram, and other social media outlets, there is an increasingly common and expected desire for public recognition. One way to capitalize on this is to establish non-monetary rewards through social media platforms that highlight the "Heroes of New York" or "Heart Heroes of New York City," for example. This tribute to everyday heroes can be a website that recognizes citizens who successfully perform CPR. This material can be tweeted and shared on many platforms to multiply the effectiveness of the campaign at no additional cost.

3.   Technology—Facilitating Bystander Participation

Tremendous advances in cell phone technology have led to a growing number of smartphones in use today in the United States. Harnessing the location-enabling

technology within these phones to notify trained and willing citizens is one recommendation with great promise.

a.   *Pulse Point App*

Pulse Point is a smartphone app that supports public safety agencies by notifying CPR-trained citizens of a cardiac arrest victim who is in need of immediate help. This application is location enabled and uses GPS. It alerts users by push notification and connects the dispatch data to the Pulse Point service, simultaneously dispatching advanced medical care personnel and CPR-trained citizens. The app also provides the location of the closest publically accessible AED. Such technology, for the first time, facilitates civic engagement by dispatching citizens who may not have witnessed the cardiac arrest event, but were close enough to receive notification that help is needed. This notification method will lead to greater civic engagement and more lives saved by encouraging citizens to intervene. It is recommended that New York City apply location enabling technology, such as the Pulse Point app to facilitate bystander engagement.

b.   *FDNY "Be 911" Life Saver App*

An alternative to the Pulse Point option, for NYC is to expand the capability of the FDNY "Be 911" Life Saver application. Currently, this application can guide you through the steps of compression-only CPR or locate the nearest AED, but it does not have the ability to notify the user when someone is in need of CPR; unlike Pulse Point, it is not connected to dispatch data. While this app provides a valuable service to those who encounter a person in cardiac arrest, it does not leverage the technology to realize its full potential as a lifesaving tool.

c.   *Overcoming Challenges Presented by High-Rise Structures*

In high-rise office buildings, requirements of the Emergency Action Plan should be amended to include a minimum number of CPR-trained staff to be on the premises while the building is occupied. These people can be members of the building fire brigade, floor wardens, or other members of the building's staff. High-rise office buildings already have requirements in regard to building fire, life safety, and duties that are required of

specific building personnel. These duties can be expanded to include CPR training. Because these buildings are typically required to maintain building staff on duty, the barriers to implementation should be minimized as there will not be any added hiring cost. Ideally, employers will realize the benefit and offer training to their employees, possibly with a partnership with the FDNY. In this eventual goal scenario, the need for trained building staff will be minimized, with a high percent of the building occupants trained and available to assist coworkers in the event of cardiac arrest.

In high-rise office buildings, existing communication systems should be used to alert CPR-trained staff or coworkers of the need for CPR. High-rise offices typically contain floor warden telephone systems, handheld radios, or other two-way communications systems. They provide the simplest solution for notification that a victim is in need of CPR. This communications infrastructure can facilitate notification to those trained in CPR when needed, decreasing the time until CPR is begun.

High-rise residential buildings present more barriers to implementation. High-rise residential structures are not governed by the same codes as office buildings, and thus would require slightly different solutions. For instance, there is typically less building staff on duty in residential buildings; some will have a doorman, security officer, maintenance personnel, building superintendent, or a similar position. It is recommended that code changes be implemented to require some building staff to be on duty 24 hours a day for buildings over a to-be-determined height. This person's duties should include recalling the elevators to aid in a quicker first responder response and being CPR-trained to render aid.

In high-rise office and residential buildings, requiring building staff to receive and maintain CPR qualification immediately increases availability of nearby trained bystanders thereby increasing the likelihood of CPR for OHCA. Additionally, partnerships between the FDNY, employers, and employees in high-rise office buildings and partnerships between community watch organizations and residents in high-rise residential buildings can lead to increased awareness and training in CPR for those willing and able.

Connecting building occupants to the need for CPR presents another challenge in high-rise buildings. A call to 911 does not notify building occupants of the need for CPR. A mechanism to simultaneously notify building occupants needs to be developed. One possible solution would be a building-specific app that ties into the dispatch data. Pulse Point, Nextdoor, or the FDNY Lifesaver App can be modified to accomplish this goal, creating a mini or micro community within a building. Another option would be to incorporate radio frequency identification or near field communication technology. These technologies are often embedded into employee ID cards or cell phones. Other solutions may involve technology that has yet to be perfected, or a simple, low-tech solution in which a person notifies building staff stationed in the lobby for relay throughout the building communication infrastructure.

C.   CONCLUSIONS

A smaller window of opportunity requires different thinking to save lives. Viewing bystanders as the "first" first responders represents different thinking. While NYC has made improvements to deal with low survival of OHCA, cardiac arrest survival rates are still lagging due to first responders' impeded arrival time.

The research presented in this thesis has identified bystander participation as one method to bridge the gap between when cardiac arrest begins and when first responders arrive. Many of these recommendations are interrelated, and efforts should be made to implement them concurrently to maximize the benefit from each. For example, targeting training to those most likely to be in a position to help around the community provides many trained citizen responders, but alone lacks a method of notification. Additionally, a public education campaign absent ample and available pubic CPR training courses may lead to a frustrated public willing to be trained but unable to find a CPR class.

Fortunately, through the examination of successful examples and other data, this thesis has identified quantifiable measures that have led to increased bystander engagement. The recommendations, centered on increasing bystander CPR are based primarily on these successful examples with the aim of saving the savable and preventing needless deaths.

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